THE
MOTOR MANUAL

A PRACTICAL HANDBOOK DEALING WITH THE WORKING PRINCIPLES, CONSTRUCTION AND MANAGEMENT OF ALL TYPES OF MOTORCARS, WITH CHAPTERS ON SPECIAL TYPES OF MOTORS, CARBURETTERS, IGNITION SYSTEMS, TRANSMISSION GEARING, PNEUMATIC TYRES, DETACHABLE RIMS AND WHEELS, THE SELECTION, DRIVING, MANIPULATION, CLEANING AND MAINTENANCE, REPAIR AND ADJUSTMENT OF MOTOR-VEHICLES, WORKSHOP NOTES, DICTIONARY OF TECHNICAL TERMS, USEFUL H.P. AND SPEED TABLES, CHARTS, FORMULÆ, HINTS FOR THE NOVICE, TAXATION, LEGAL MATTERS, TOURING, ETC., ETC.

ILLUSTRATED BY SPECIALLY PREPARED DIAGRAMS

Compiled and Illustrated by the Staff of " The Motor.

Seventeenth Edition

(Revised)

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THE MOTOR MANUAL.

17th Edition.

PREFACE

THE continued progress in the design and equipment of the motorcar, and the introduction of many useful novelties, has called for extensive revision of this edition. The proportion of new text is unusually large, and every effort has been made to maintain, and where possible improve on the high standard of the illustrations. In quantity also of illustrations this edition, the 17th, is in advance of any previous one. The section dealing with engine theory and principles has been carefully revised and extended, and several new types of engines are dealt with in an interesting manner. The large part of the book devoted to a detailed consideration of the transmission, general mechanism, and constructional work of a car has been brought up-to-date. The working of a gearbox has received new treatment, and many new explanatory diagrams included on gearing and transmission details. The ignition section is greatly improved and all up-to-date developments in connection with the magneto are dealt with and additional diagrams on magneto principles are included.

One of the most important features of this edition is the extensive treatment given to automatic engine starters and electric lighting. Concise information is given of all recent developments. Here, again, the explanatory diagrams should prove a great help to the beginner as well as the user. Several additions and revisions have been made in the section treating of tyres, and in the descriptions of general accessories and tools many practical hints will be found.

The revised section devoted to the choice and management of a car, as before, is a large one, and from this it is hoped that the prospective buyer of a car will find it of much practical value.

Many new hints are to be found in the repairs and adjustments section, and important revisions and additions have been made in the pages dealing with electrical and mechanical terms, formulæ, etc., and some new treatment and diagrams of power testing appliances will assist in solving the difficulties that often arise as to what power precisely means.

The fuel question has developed to one of such prime importance that considerable extra space has been given to it in the chapter on carburation. Benzole, the only proved practical alternative to petrol, has several pages devoted to it and many practical hints on its efficient use are included.

The touring and legal chapters have been carefully revised and several recent developments taken due note of.

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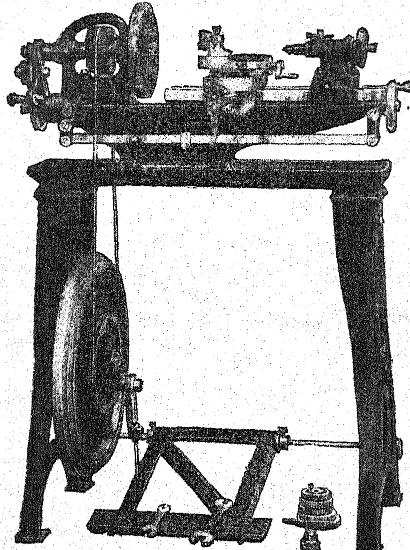
TO RE-BUSH A CONNECTING ROD,

to true up valves, make tappets, piston rings, etc., to do a hundred and one running repairs, to fit accessories and make replacements—the most economical, most convenient and most expeditious way is to install in the garage a Drummond 3½ in. lathe. For this class of work no more handy lathe could be found; it is designed for the work and is sold at a price that makes it a paying proposition.



May we send you full particulars of this 3½ in. centre, self-acting, sliding, boring, screw-cutting, back-geared, gap-bed lathe. We shall be pleased to, and to give information as to complete installations of garage tools. Price of this lathe as shown ... ... £14 - 17 - 0

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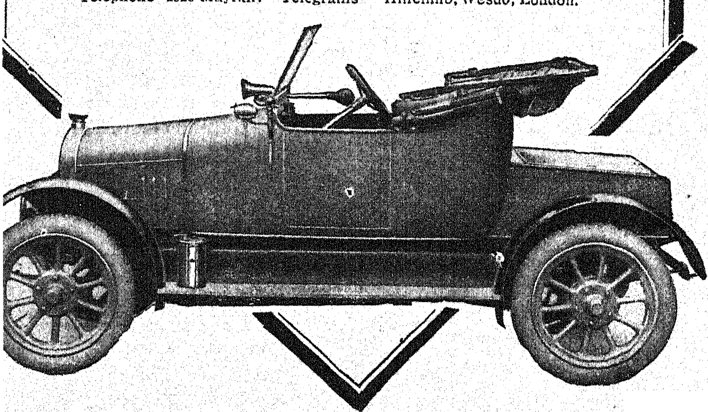

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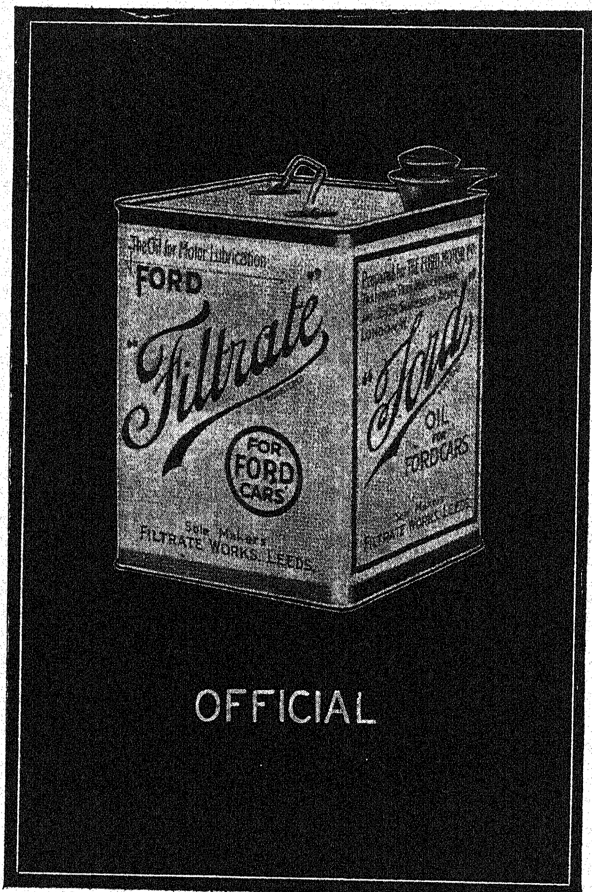
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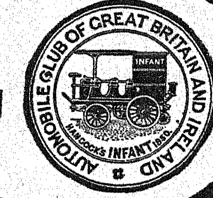
The

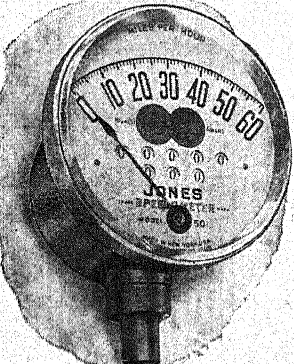
JONES SPEEDOMETER



GOLD MEDAL AND HIGHEST AWARD AMONG SPEEDOMETERS BY THE ROYAL AUTO CLUB—GOLD MEDAL ALSO TURIN EXHIBITION. :: :: ::

JONES SPEEDOMETERS are constructed on the centrifugal gyroscopic principle, entirely unaffected by temperature changes or the proximity of magnetic or electrical devices. Its principle is that of a natural law, as unalterable as the law of gravity, and positively constant.

Every single instrument is individually calibrated by expert instrument makers, and their accuracy is endorsed by the highest authorities the world over.



The MOST DEPENDABLE—
The MOST ACCURATE—
SPEEDOMETER IN THE WORLD.

WHAT FOLKS SAY:

MR. H. V. PRESCOTT,
of Roselands,
Park Road,
Timperley, Cheshire,
writes:

"Perhaps the following will be of interest to you. I was summoned at Middlewich (Cheshire) for driving to the danger of the public on 3rd Sept. There were four witnesses against me. My only witness was the Jones Speed Indicator with maximum hand, but I won the case—its evidence being accepted. I reckon the Jones saved me £5."

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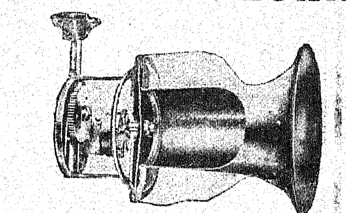

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SEVENTEENTH EDITION

THE MOTOR MANUAL

CHAPTER I

The Petrol Motor: General Principles of Operation

The petrol motor now universally used for road locomotion is the most convenient, economical and practical means available of obtaining mechanical power directly from liquid fuel. Although it is generally termed "petrol" motor, this is nowadays somewhat of a misnomer, as the same type of motor or engine can be driven by other fuels than petrol (a spirit derived from petroleum), such as benzole, paraffin, alcohol, and also by coal gas. The longer expression of "internal-combustion engine" is a more comprehensive but less convenient one. It implies that the power is produced by direct combustion of the fuel within the engine itself. The steam engine produces its power in a much less direct manner, as the fuel has to be burnt within a boiler to generate steam, which has to be conveyed into the engine. The method, therefore, does not compare favourably with that of internal combustion, either for convenience or economy. It is, however, interesting to note that the earliest attempts at road locomotion were made with steam engines. Thus Cugnot's steam carriage, now in the Paris Science Museum (Conservatoire des Arts et Metiers) made in 1769. In England, between 1826 and 1838, steam-propeller buses ran with varying success on some of the roads running south and west from London.

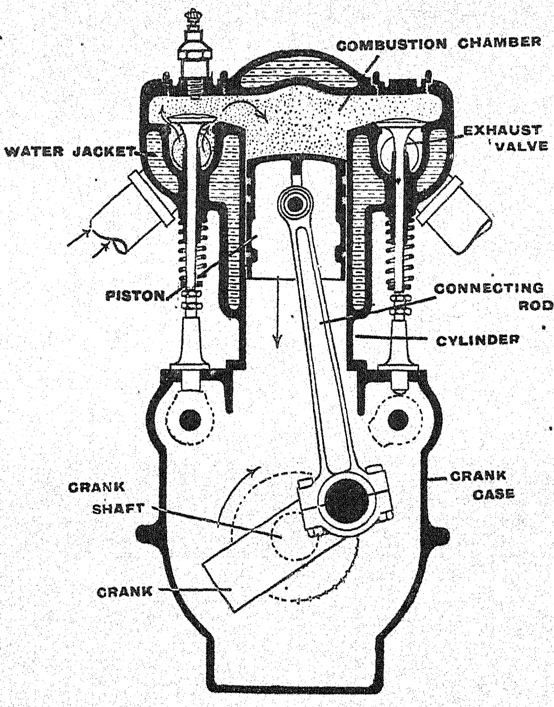
Early Types of Internal-combustion Engines

The ordinary gas engine, introduced some 50 years ago, has most of the leading features of a petrol motor, and it is from this principle that the pioneer inventors of the petrol motor, such as Benz, Daimler, and Levassor worked out their designs. The earliest types of gas engine producing power by the explosion of a "charge" of air and coal gas within a cylinder had the fundamental parts of the present-day internal-combustion engine, viz., cylinder, piston, connecting rod, crank, flywheel, valves, and some means of ignition such as a small flame or spark. The successive explosions of the charges of gas and air were utilized to drive forward the piston, the motion being converted into rotary motion by the crank. The explosive charges were automatically drawn into the cylinder by utilizing one of the forward strokes as a pump.

Single and Double Acting Engines

The internal-combustion motor or engine is termed "single acting," from the fact that the pressure acts on one side of the piston only, whereas in an ordinary steam engine the pressure acts on both sides alternately. This necessitates the use of a piston rod and glands, and renders the construction considerably more complicated than an internal-combustion engine as applied to motorcars. In the petrol motor the same general principles apply: it is a highly-developed gas

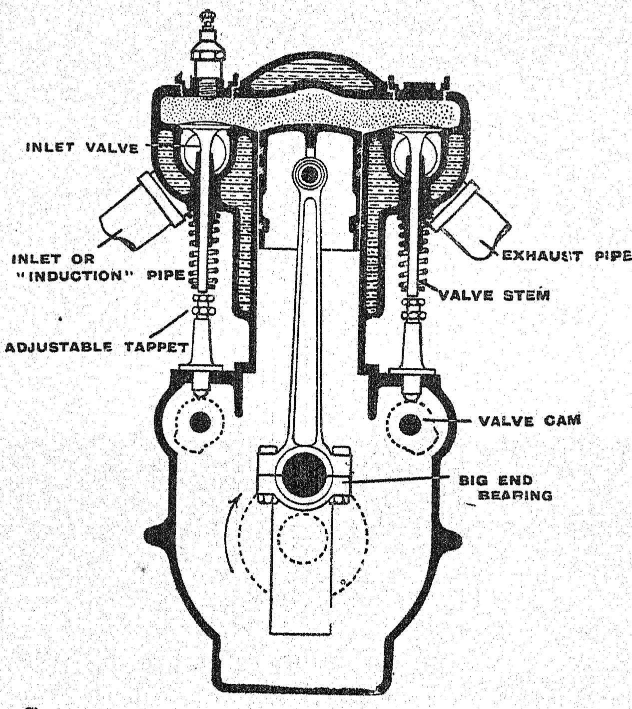
engine. The main characteristics are expressed in everyday terms—"great power in a small compass," lightness, simplicity, high efficiency and economy, and thus it has proved to be the practical ideal for driving a road vehicle. The petrol or other fuel may be regarded as liquefied gas. An enormous amount of latent energy is stored up in a small bulk of petrol—a valuable characteristic. The petrol motor has the following fundamental parts: a cylinder, piston moving freely in the cylinder, but fitting it closely and pressure tight by means of spring rings, a connecting rod, crankshaft, flywheel, valves to admit



Admission of the charge of petrol vapour and air. Inlet stroke. (Note inlet valve on left-hand side of cylinder is open.)

and release the explosive charge and burnt gases to and from the cylinder. The valves are worked by a simple mechanism consisting of toothed wheels and "cams," the latter best described as a rotating metal (steel) part with a peculiarly-shaped curved edge (described and illustrated on page 6). The cylinder is maintained at a practicable working temperature, about 185 degrees F., by continually circulating water around it—the cylinders are, in fact, water-jacketed. It will be easy to follow that, with the continual exploding of the charges in the cylinder, heat would be accumulating, and unless means were adopted for keeping down this accumulation of heat, the cylinder would quickly become red hot, lubrication of the piston would be impossible, and the motor would soon stop work. Water is the best

medium for extracting this surplus heat from the cylinder walls. Water has a very high capacity for heat, so that there is little or no danger of overheating, providing the water circulation is maintained continuously around the cylinder. The water is cooled in the process by passing through a "radiator," or series of thin copper tubes, compactly arranged, offering a large surface to the air. For quite small engines, under 4 h.p., water cooling is not a necessity. By having flanges or radiators cast on the cylinder the air passing over them will keep the temperature down to a workable degree.



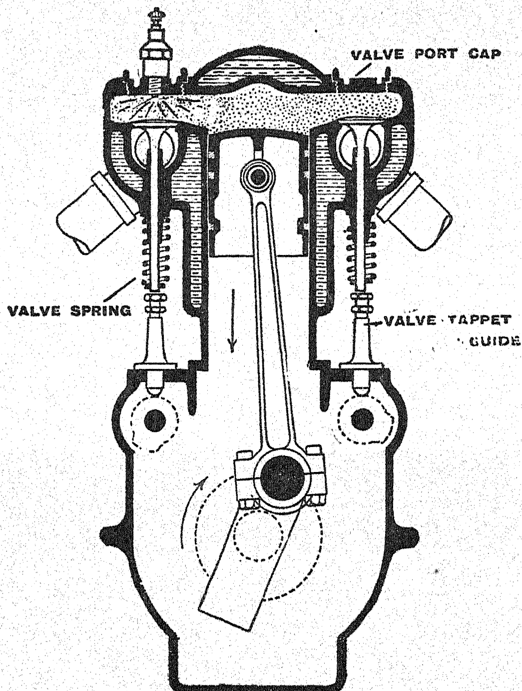
Charge of explosive mixture of fuel vapour and air fully compressed: Compression stroke; both valves shut. Piston at top of its stroke. Crank on top dead centre.

It is possible that ultimately water cooling, with its complication and extra weight, will be rendered unnecessary, but it is likely to be retained for a considerable period till the perfect air-cooling system comes along. Despite some drawbacks, the modern systems of water circulation are highly efficient.

The Four-stroke "Cycle" of Operations

In the petrol motor, only one stroke of the piston out of every four is a "power" stroke giving motion to the crankshaft, the other three strokes performing a series of operations which are indispensable

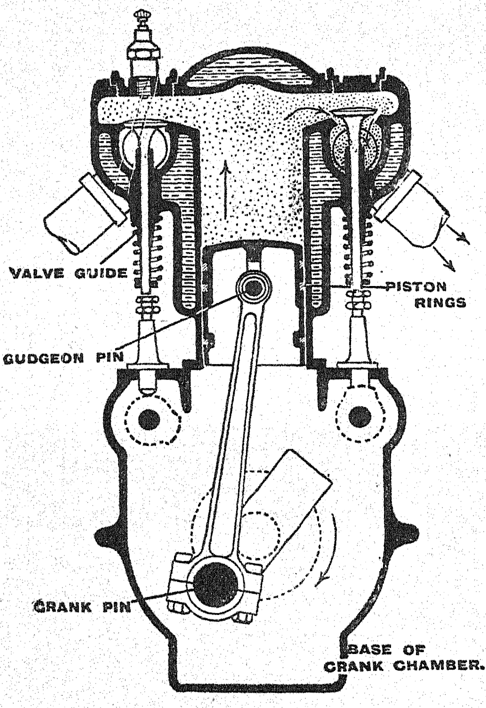
factors in the general working principle. Take the beginning of a complete "cycle" of operations to get a clear idea of the system. First, there is the admission stroke, in which the piston descends creating a partial vacuum, and the "inlet" valve opens simultaneously, being lifted off its seat by the cam, and a charge of explosive "mixture," automatically prepared in a gas-making device known as a "carburetter," is sucked into the cylinder. When the piston has reached the end of its down stroke, the "inlet" or admission of gas is completed and the valve closes. The second stroke now begins, the piston rises again and



Explosion of charge by an electric spark. Impulse or power stroke both valves shut. The spark occurs between the points of a sparking plug, seen on the left-hand side of the cylinder. The initial pressure on the piston at the instant the spark occurs is 250-300 lb. per sq. inch. As the piston descends the pressure falls off to 40-50 lb. at the end of the stroke.

compresses the charge, and reduces the original volume of gas to one-fourth, or rather less. This stroke is termed the compression stroke, and is a vitally important factor in the efficient working of the motor. If there is any loss or leakage of the gas under the compressing effect of the rising piston there will be a loss of power. The effect of compressing the gas into a very small volume is to render it capable of exploding with much greater energy than it otherwise would. In the compression of the charge a very considerable amount of heat is given to it, representing so much of the energy which the flywheel stores up.

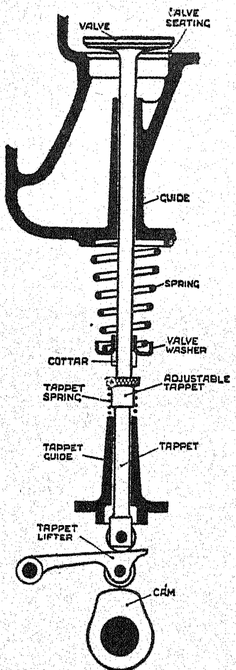
The average amount of compression used is 85 lb. per square inch; some engines go as high as 95 lb., but there is a limit to the compression which can safely be used. If it exceeds the above figures to any extent it is quite possible for the charge to explode spontaneously. The degree of compression depends upon the size of the "clearance" volume or space above the piston when at the end of its stroke. The compression stroke being completed, the charge of gas is ready for firing, and this operation is performed by an electric spark occurring in the compression chamber just at the exact moment. The spark is produced by the



Expulsion of burnt charge. Exhausting stroke; exhaust valve on right open. Gases discharged through the pipe shown into a silencer, which reduces the pressure to nearly that of the atmosphere, and thus prevents the exhaust making a loud noise.

current from a magneto passing between the two points or electrodes of a sparking plug. The moment of firing, or the "ignition timing," can be varied, that is to say, the electric ignition arrangement is so devised that the spark can be made to occur either before the compression stroke is finished or afterwards, that is, when the piston is descending. In the former instance the ignition is said to be advanced, and in the latter retarded. The reason that such variation in the time of firing is necessary is that the ignition of the charge and development of the full pressure of the explosion are not quite instantaneous, and to be able

to apply the full pressure of the explosion to the piston at the most favourable position of the crank, it is necessary to ignite the charge of gas and air a short period in advance of the piston movement. With high-tension magneto ignition a very small amount of timing variation suffices. In some cases the timing period is fixed for the magneto. To be able to start the engine without risk of a "back stroke" of the starting handle injuring the operator, a certain amount of retardation of the ignition is desirable. The power stroke having been accomplished, there, of course, remains in the cylinder a considerable volume of burnt gas under pressure, which must be got rid of as quickly as possible, and it is, therefore, exhausted. Just before the piston reaches the end of its down (firing) stroke the exhaust valve opens, and remains open the whole time the piston is completing the up stroke. The burnt gases are thus swept out through a "silencer" into the air, the ejection also being aided by the fact of the gases still being at

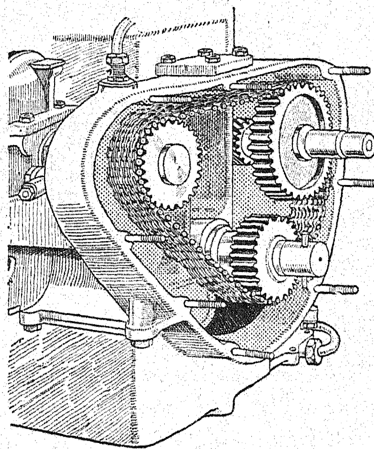


Showing ordinary poppet or "mushroom" valve mechanism complete and port leading from combustion chamber to silencer. The adjustable tappet enables the "lift" of the valve to be maintained at full amount. As the result of the continual hammering when in action, the valve stem shortens and any undue clearance may be compensated for at the tappet. Close adjustment also ensures quiet working of the valve. The side thrust of the cam is usually taken by a hinged lever fitted between the cam and valve tappet. In some engines the cam actuates the tappet directly, the small spring under the tappet keeps it in close contact with valve stem and prevents undue noise and shock. Most engines now have the valves "all-enclosed" for quietness in working. The valve stems, springs and tappets are enclosed in a casing having a detachable cover.

considerable pressure (30-40lb. per square inch). It is usual to open the exhaust valve some little time—approximately equal to one-sixth of the stroke—before the firing stroke is complete, to facilitate the clearance of the gases. This is termed giving the exhaust valve a "lead." It might be thought that this would reduce the effectiveness of the power stroke, but a little consideration will show that, by the time the valve begins to open, the crank is at a position where it has very little leverage, and the exploded gases are doing no effective work, and,

therefore might with advantage be released, and this is always done. Thus the four operations, viz., inlet of charge, compression, explosion, and exhausting are completed and "cycle" of four strokes performed.

Timing gear system in which a "silent" chain is used instead of pinions. The object is to obtain smoother and quieter running. The crankshaft chain-wheel is on the lower right hand side and this drives at half speed the valve camshaft chain-wheel on right of twice the diameter. The same chain drives the magneto shaft which has to run at the same speed as the crankshaft. Any undue slack in the chain can be taken up by sliding the magneto-shaft outwards. This chain is self-adjusting for pitch.



Working of the Valves

The working of the valves, as will have been noted, is of vital importance in the "cycle" of operations. The principle and working of the valves will be followed by studying the diagrams. A valve consists of a nickel-steel stem or spindle carrying a "head" at one end, this having its edge bevelled off, and fitting closely on to a seating. The tension of a strong steel spring keeps the valve head hard down on this seating, so that the valve is then spoken of as being closed or shut. The opening of the valves at the correct time is performed by means of cams, rotating steel pieces with curved edges, operated by a simple piece of gearwheel mechanism from the main shaft of the motor. As it is necessary that the valve cams should only rotate at one-half the speed of the motor shaft, the gearwheels are proportioned so as to obtain this result, the wheel on the camshaft being made twice the diameter (having twice the number of teeth) as the wheel on the motor shaft. It is sometimes spoken of as the "two-to-one gear," or the distribution gear.

Improvements in Valves

Formerly the ordinary "poppet" valve, as just described, gave rise to considerable noise when operating. Nowadays, it is practically noiseless. This result has been obtained by making the valves of smaller lift, but with greater area of opening. The tappets are usually provided with fibre "heads" to deaden the impact, and finally the valve is all-enclosed by a detachable cover plate.

CHAPTER II

Various Types of Engines

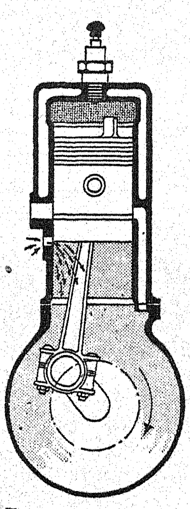
The Two-stroke

A type of motor different in principle from the four-stroke type described is the two-stroke motor, in which the power impulse occurs once in every revolution instead of once in two revolutions, as in the former type. A special feature of this engine is that there are no "valves" (as understood in the general meaning of the term, and as just described) to admit and release the gas to and from the cylinder. The working piston is made to serve for opening and closing ports or passages in the

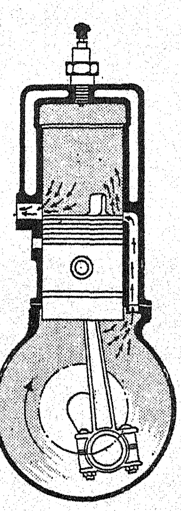
Simple form of two-stroke motor (the crankcase is shown larger than actually obtains in practice). The path of the gases is depicted by the arrows.

Cycle of Operations.

1st half revolution: piston descends, charge exploded and partly exhausted, fresh charge slightly compressed in crankcase, fresh charge enters cylinder and displaces burnt charge. 2nd half revolution: fresh charge fully compressed in cylinder, partial vacuum formed in crankcase by the rising piston and fresh charge sucked in through the inlet port leading to crankcase. The fresh charge of mixture is directed upwards by the deflector or baffle on the top of the piston and thus kept as far as possible from direct contact with previous burnt charge.



Fresh charge entering crankcase whilst the charge in top of cylinder is being compressed prior to explosion.

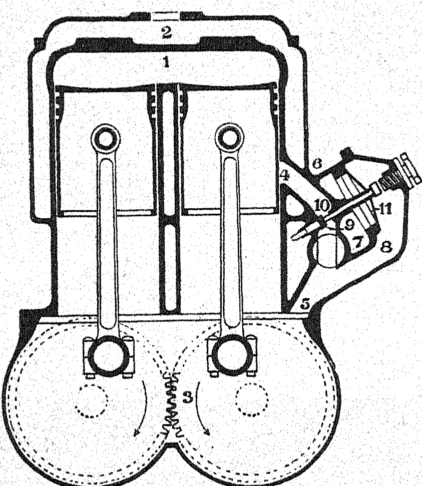


Cylinder charge exhausting after explosion via exhaust port on left. Fresh charge, moderately compressed in crankcase, entering by port on right and deflected upwards.

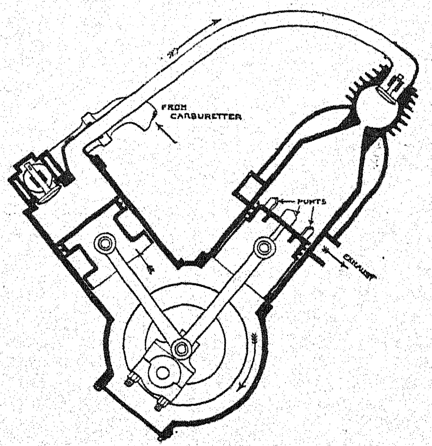
cylinder, through which the gas enters, and is also released after explosion. The explosion is effected by means of an electric spark. A reference to the illustration will explain how the series of operations occurs. The crankcase is gas-tight, but has an aperture at the top (actually, it is formed in the cylinder), opened and closed by the piston, which, when clear of the aperture, allows a charge of explosive mixture to rush in, owing to the partial vacuum created by the upward

movement of the piston. A passage connects from the crankcase to the cylinder inlet port. The key to the action of this type of motor is that the piston is made to perform two operations in one stroke; thus, when the explosion takes place on one side, the other side partly compresses the charge in the crankcase. A further descent of the piston uncovers a port, and the partly-compressed gas rushes into the cylinder. On the next stroke the rising piston fully compresses the charge (meanwhile a fresh charge enters the crankcase), and at the end of the stroke ignition occurs. The piston does not sweep out the burnt charge as in the four-stroke

Special Two-stroke Motors

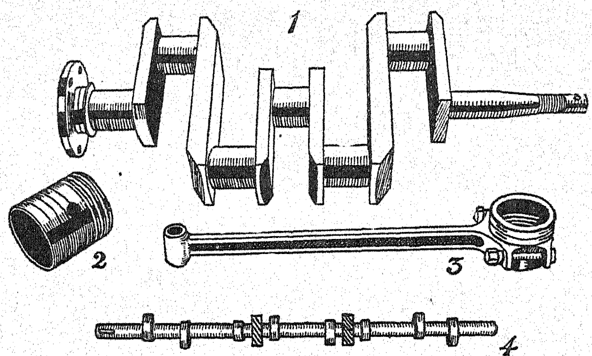


The "valveless" two-stroke motor is a special two-cylinder type, with a single combustion chamber and crankshafts geared together (3). The upward movement of the pistons causes a vacuum in the crankcase, and air enters by ports (7) and (8) through air valve (11) in carburetter (6). This valve has a long stem (10), with needle-valve at end, seating into petrol jet (9), which, on lifting, admits petrol into surrounding chamber. When pistons descend, the air in crankcase is compressed till inlet port (4) is uncovered by pistons, when air takes up the petrol in jet chamber and enters cylinder. Simultaneously the exhaust is swept out, and a fresh charge compressed in combustion space (1), after which ignition and explosion occur, driving the two pistons downwards. The cylinders are water-jacketed (2). The exhaust ports are not shown. The power is taken from one of the crankshafts.



This motor has an independent compressing cylinder (shown on left side). The charge is drawn into the pump and partial compressing cylinder through a non-return valve. This charge is forced into the working cylinder, through the branch pipe and valve connecting the two, as the piston is completing its firing stroke. The charge is retained, compressed and fired in the usual manner. It will be noted that the pump cylinder has a shorter stroke than the working cylinder.

motor, but this escapes by virtue of its own pressure, the fresh charge of mixture entering simultaneously and helping to displace it. The advantages of this type of motor are its striking simplicity, absence of valves, and the fact that it runs with less vibration than the four-stroke pattern, on account of the impulse occurring every revolution. On the other hand, it is not considered so economical of fuel as the four-stroke type; and there is a danger of premature ignition if the burnt charge is not cleared out quickly. A difficulty sometimes arises from the fact that the lubricating oil in the crank chamber mixes with the charge, reducing its explosive power and causing ignition troubles from fouling the sparking plug points. There are several modifications of the two-stroke principle just described, in which its defects are minimized or



Four-cylinder long-stroke engine details.

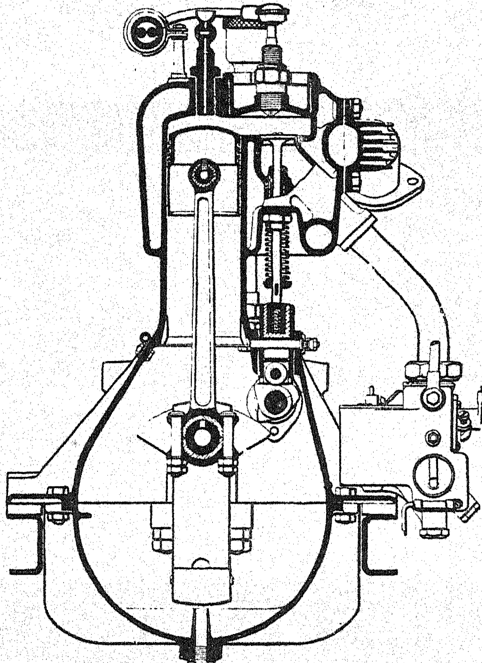
(1) Crankshaft with three bearings.
(2) Light steel piston.
(3) Light connecting rod.
(4) One-piece cam-shaft.

overcome. In one special form an auxiliary cylinder is used, which acts as a pump for the charge instead of the crankcase, and thus it is not contaminated in any way, and has the further advantage that it sweeps out the burnt charge. Another form, which has been applied for car-driving, has two cylinders, but with a single combustion chamber. Two-stroke engines have also been constructed on the double-acting principle, an explosion occurring on each side of the piston alternately. The charges are admitted into and compressed in an independent cylinder.

The Modern Car Engine

The four-cylinder engine has long since displaced the singles and two-cylinder types. The former is never used now, and only for quite small and light cars does the two-cylinder find any application. The four-cylinder engine can now be made in quite small power sizes, even as small as 52 mm. in the bore and developing about 8 b.h.p. A brief study of the two-cylinder engine, however, is desirable as it assists in an understanding of the four-cylinder. The cylinders are usually arranged with their axes parallel to each other, or are placed side by side, although a few have been made with the cylinders fixed horizontally, end to end, and axes in line. The cranks may be set either together or at 180 degrees to each other. The sequence of operations in each cylinder depends on how the cranks are set. Supposing the two

connecting rods drive on a single crank, and thus the two pistons move up and down together, the cycle of operations would be:—



Section of a modern long-stroke engine, with carburetter

Cylinder A.		*Cylinder B.*
Inlet	... ...	Explosion
Compression	... ...	Exhaust
Explosion	... ...	Inlet
Exhaust	. ...	Compression

In this arrangement an impulse for each revolution of the crankshaft is obtained; but, as will be obvious, it is difficult to get a good balance of the moving parts with two pistons, connecting rods and cranks all moving together in the same direction. In the other arrangement, which is the one usually adopted, the cranks are set at 180 degrees. A good mechanical balance is obtained, but the two impulses follow in close succession, so that the driving effect or "torque" on the shaft is less steady than in the other system. The sequence of operations is then as follows:—

Cylinder B.		*Cylinder A.*
Inlet	... ...	Exhaust
Compression	... ...	Inlet
Explosion	... ...	Compression
Exhaust	... ...	Explosion

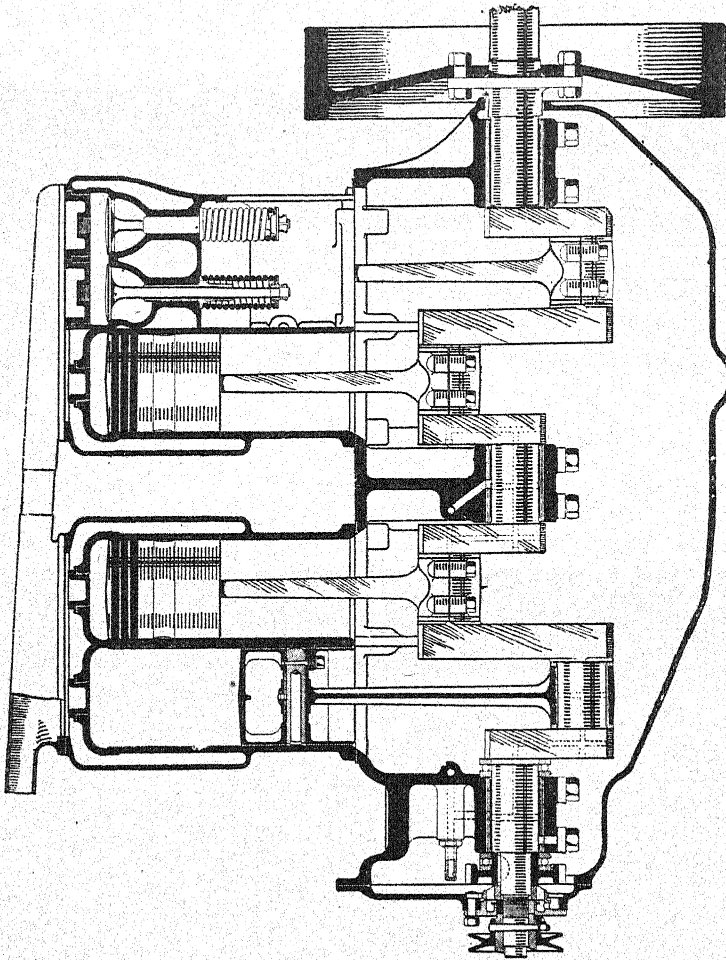


Diagram of a Standard Four-cylinder Engine

Illustration in part section of a standard type four-cylinder engine. A section of one piston is shown, and one cylinder and piston at the right-hand end of the engine are not shown. In place of them appears the valves for one cylinder which explains the general arrangement of the whole series. The valve camshaft and tappets are not shown.

The Four-cylinder Engine

This is now the universally-adopted type of engine, and its construction and working will readily be understood from a knowledge of the two-cylinder just dealt with, as it practically consists of a pair of two-cylinder engines of the 180-degree crankshaft type set in line. The four cranks are all in the same plane, the two centre cranks having their crankpins in line and the two end crankpins being also in line. This arrangement, as a little consideration will show, results in the first and fourth pistons moving up and down simultaneously, and the two central pistons moving together, but in an opposite direction to the other pair. This principle results in a relatively good balance of the moving parts. Using light pistons and connecting rods, a high speed of revolutions can be obtained with a minimum of vibration.

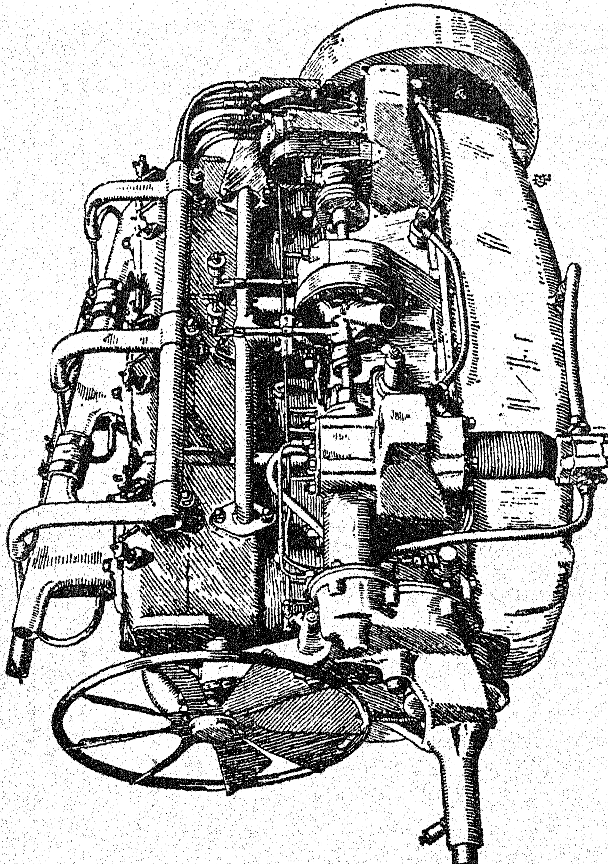
Sequence of Firing Steadiness of Torque

The four-cylinder engine has a power impulse for each half revolution of the crankshaft, or two impulses per revolution. The continuity of turning effort or "torque" is practically steady, each cylinder taking up the firing successively; there is no actual no-power interval, as is the case with the two-cylinder engine. The series of operations, i.e., induction of explosive charge, compression, explosion, and exhaust, can be understood from a study of the two-cylinder 180 degrees type of engine. Thus, if the cylinders are numerated in simple order 1, 2, 3, 4, assume No. 1 cylinder is on its inlet stroke; its piston is descending, and No. 2 piston is rising on the compression stroke. No. 3 piston will also be rising, but it will be on its exhausting stroke. No. 4 piston will be descending similarly to No. 1 piston, but it will be on its firing stroke. A down stroke must either be an inlet or a firing stroke, and an up stroke a compression or an exhaust stroke, so that, knowing what one cylinder is doing, it is a simple matter to know what the other one is doing.

It is usual now to adopt a standard sequence of firing; the cylinders do not actually fire in the simple order: 1, 2, 3, 4—1, 2, 3, 4, but 1, 2, 4, 3—1, 2, 4, 3. This, however is not the only possible sequence, as a consideration of the cycle of operations will show that as No. 3 cylinder is making a down stroke simultaneously with No. 2, it can either be a firing or inlet stroke, according to how the valve cams are arranged. Thus, the firing sequence can be 1, 3, 4, 2, but not many engines have this sequence of timing.

Chief Features of Engine Construction

The four cylinders are in the majority of instances cast "en bloc," i.e., in one casting. This provides compactness and rigidity. Some engines have the cylinders cast in pairs. The valve ports and gas passages are formed internally in the casting in many cases, thus avoiding the use of outside piping, there being only one connection each from the carburetter and silencer. The valves may either be all on one side of the engine, or the inlets on one side and the exhausts on the other. Each system has its advantages; the former only require a single camshaft, and the engine construction is thereby simplified, and the majority of engines are made this way. The whole of the valve stems and tappets are enclosed by a cover plate, thus ensuring quiet working and neatness. The sparking plug usually is screwed into the cap over the inlet valve, where it comes directly into contact with the fresh explosive mixture. Some few engines have the sparking plug in the centre of the cylinder head, which is theoretically the best position.



A standard type six-cylinder engine, cylinders set in pairs. Complete equipment of carburetter, pump, magneto, cooling fan, etc.

The crankshaft is always made in one piece from a chrome-nickel-steel forging, and, except in a few cases, it runs in a central bearing, in addition to a bearing at each end. This ensures the absence of any "springing" of the shaft, which would cause vibration. Steel pistons are being largely adopted, as a considerable saving in weight is effected thereby as compared with cast-iron pistons. This tends to eliminate vibration usually resulting from heavy reciprocating parts.

Accessibility of Parts

The up-to-date engine is much freer of piping and fittings than earlier types; and it is thus a much easier matter than formerly to reach such parts as the carburetter and magneto if adjustment is required. The valves are easily removed by unscrewing the valve caps, sparking plugs are always accessible, and the inspection plates in the crankcase give access to the connecting-rod ends. Some engines are designed so that the pistons can be taken out of the cylinders without removing the latter.

Six-cylinder Engine

As a standard type the six-cylinder engine comes next in importance to the four-cylinder. A few years ago it was only adopted for large, high-powered cars, but nowadays it is made in medium-power sizes, i.e., 15 h.p. to 20 h.p., and is becoming increasingly popular. It has a remarkably smooth and even torque or turning effort, and the balance of the working parts is so good that vibration even at the highest speeds is eliminated. It is a very "flexible" type of engine, and therefore the need for gear changing is reduced to a very small amount except in cases where the power available is small for the work it has to do. A wide range of power is available by throttle control alone, and for this reason the driving is proportionately easier than with a smaller number of cylinders. A former drawback of the six-cylinder engine was its undue length. This fault is non-existent nowadays, as the improved methods of casting the cylinders "en bloc" enables this engine to be made very compact, especially as the practice now is to limit the cylinder bore to small dimensions. In its construction the six-cylinder differs from the four chiefly as regards the shape of the crankshaft. The other components—pistons, connecting rods, valves, etc—are the same. The four-cylinder crankshaft, it will have been made clear, has all its "throws" in one plane: that is, the whole crankshaft can be laid flat. The six-cylinder crankshaft, however, has its throws in three planes, each throw being at an angle of 120 degrees. This will be easily followed by reference to the diagram. To study the "cycle of operations" of this engine the simplest plan is to consider the firing order, which is 1, 4, 2, 6, 3, 5. The cylinder No. 1 will not quite have reached the end of its firing stroke by one-sixth when cylinder No. 4 will have just started its firing stroke. This means that there is no actual "dead" or no-power period between the two strokes, but a slight overlapping. No. 2 cylinder will simultaneously be compressing its charge, and before the firing stroke of No. 4 cylinder is complete by one-sixth it will have started its firing stroke. No. 6 cylinder will similarly be compressing its charge, and takes up the firing just before No. 2 cylinder finishes it. Likewise cylinders 3 and 5 come into operation in proper sequence, the "cycle" then starting again from No. 1. The important feature is that power is being applied to the crankshaft the whole period of its revolution, and there is a slight overlapping of the power stroke of one cylinder by the next in its order of firing.

The inlet and exhaust strokes follow in their proper sequence as in a four-cylinder. with the slight difference that there is the same

small amount of overlap between successive cylinders as in the firing stroke. It will be noted from the order of firing that the power is applied to the crankshaft at various points. There is not, as it were, a "ripple" of firing strokes from cylinder No. 1 right along to cylinder No. 6. As compared with the actual number of power impulses per crankshaft revolution of the four-cylinder engine, the six-cylinder gives three impulses; hence the improved turning effort on the crankshaft. It is the usual practice to construct the six-cylinder crankshaft from a one-piece chrome-nickel steel forging. From the comparatively complex arrangement of the crank-throws it will follow that the turning and grinding of the shaft is a more difficult piece of machine work than a four-cylinder, and in fact it can only be properly done on specially-designed machinery.

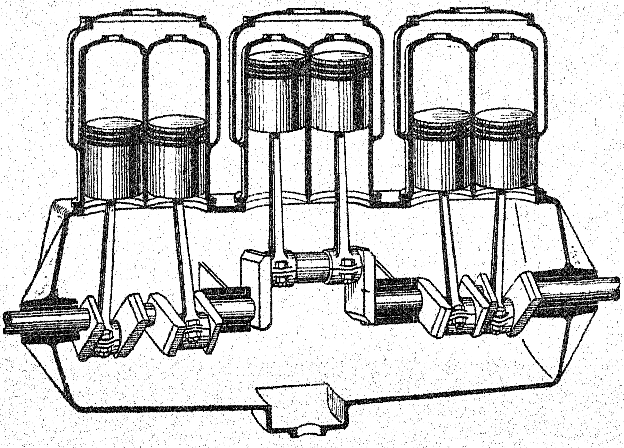
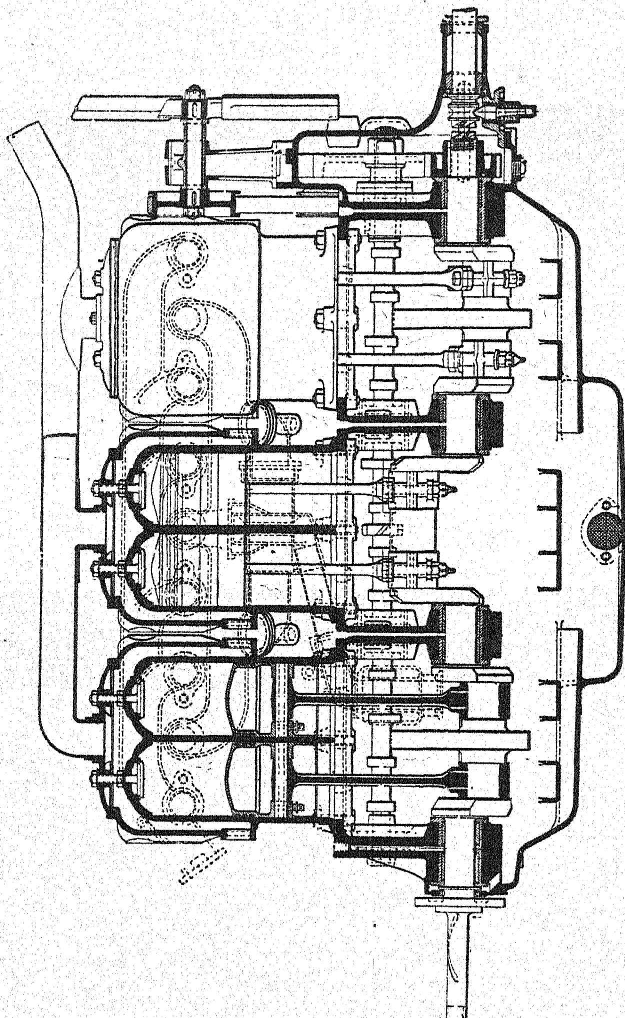


Diagram explaining how the cranks are arranged on a six-cylinder engine. It consists practically of two engines, each of three cylinders, coupled together, the centre cranks and each consecutive pair being in the same plane. The cranks (viewed from each end) are set at 120 degrees relative to each other, except the third and fourth.

The Eight-cylinder Engine

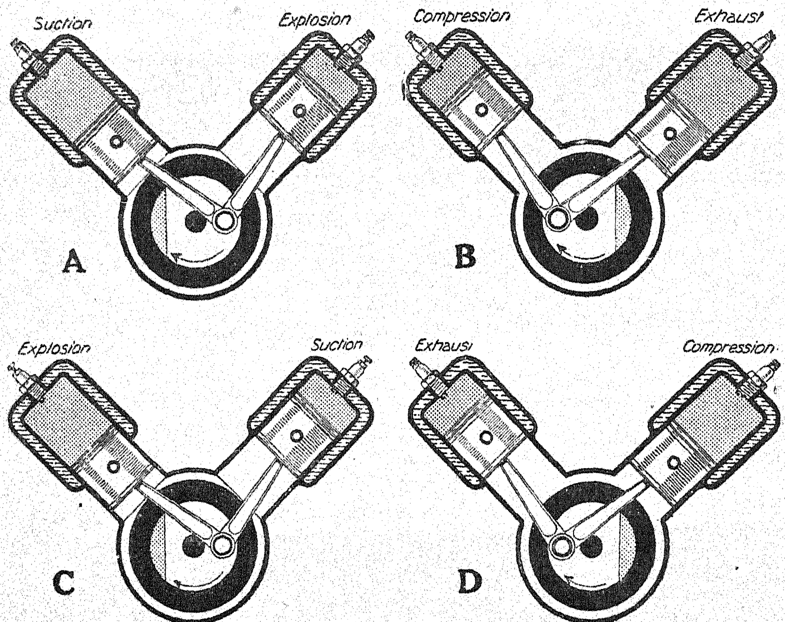
This is a type distinct from the four and six-cylinder. Instead of the cylinders being arranged in one long row, which would obviously mean that a great deal of space would be taken up, it consists of two rows or blocks, each of four cylinders, arranged V fashion. Thus it is no longer than a four-cylinder of similar cylinder dimensions, although taking up more space from side to side. The space between the two rows, however, is utilized to mount the carburetter and other details. The crankshaft is practically the same as that of a four-cylinder engine, but provision is made so that the connecting rods of two cylinders can drive on to one crank. With the increased number of cylinders the torque and flexibility of this type of engine, it is claimed, are superior to the four and six, and the excellent balance obtained eliminates all vibration. The order of firing is somewhat complex. Looking at the engine from the forward end and numbering each set of cylinders from the rear end: Left 1, 2, 3, 4. Right 1, 2, 3, 4, the sequence is:—L1, R4, L3, R2, L4, R1, L2, R3.



Section of a six-cylinder engine with cylinders cast in pairs. The arrangement of crankshaft bearings is well shown, also the means of positively lubricating same by an oil lead passing vertically down to them. The connecting-rod ends dip into the oil troughs seen directly below them. All the oil drains into the lower part of crankcase, whence it is returned to lubricator by a pump.

The V-Type of Engine

In the V engine the pair of cylinders are set at an angle, generally between 45 and 90 degrees, both cylinders being in the same plane. This makes it more economical of space than having the cylinders side by side, and it is adopted to a small extent mainly for this reason.



These diagrams illustrate the cycle of operations in a V-type engine having a 90 degrees angle of cylinders. Considered in the order A, B, C, D, the respective phases of the cycle occurring for each cylinder during 1½ revolutions of the crankshaft can be followed.

Thus two cylinders can be fixed in the space occupied by one, four in the place of two, and eight in place of four. In principle the operation is this: Both connecting rods drive on to one crank, as shown. If one cylinder is on the inlet stroke the other will be compressing. Before the inlet stroke of one is complete the other cylinder will fire, so that the opposing cylinder has still part of its suction stroke to complete, and then compression takes place. Meanwhile the other cylinder is exhausting. It will be followed from this that the strokes of the two cylinders slightly overlap.

This type of engine finds some favour for very light and inexpensive cars, in preference to the vertical two-cylinder, each type of which has disadvantages, one having an uneven torque and the other a defective balance. The 90 degrees V engine has a good balance and a much less uneven torque than the other types, though not perfect in either respect.

V Engines of Small Angle

The ordinary type of wide-angle engine takes up considerable room, that is, measured from side to side, necessitating a wide bonnet, owing to the "spread" of the cylinders. An ingeniously-designed type of V engine is that in which two sets of cylinders, four in all, are set at a very small angle to each other, one cylinder merging into the other near the base. The pistons are also cut away on adjacent sides to give the necessary clearance for working. One of each pair of connecting rods has a forked end.

The Question of Long v. Short-stroke Engines

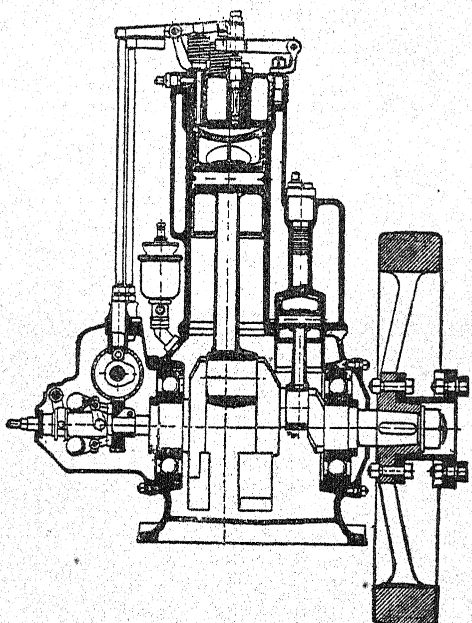
The modern engine has a length of stroke which is considerably greater than the bore; it does in some cases amount to twice the bore dimensions, but the majority of engines have less than this ratio. One explanation for this development is the principle of rating engines by bore dimensions only. The requisite cylinder capacity, that is, the amount of explosive charge it can take in per stroke, to obtain a given horse-power, has been obtained by lengthening the stroke, so that even comparatively small-bore cylinders can develop a high power. On the other hand, there are certain mechanical drawbacks of extra long strokes. There is, for example, the excessive angularity of the connecting rod, imposing a greater thrust on the cylinder walls than is caused by a short stroke. There are also questions concerning the freedom from vibration and the stability of the engine which have to be taken into account

The Diesel Engine

In its leading features this engine is very similar to the ordinary four-stroke type of petrol engine. Instead, however, of an explosive mixture being drawn into the cylinder and then compressed, to be followed by ignition by an electric spark, a charge of air is firstly drawn into the cylinder and compressed to a very high pressure, viz., 500 lb. This greatly raises its temperature, so that when at the end of the compression stroke a small quantity of heavy crude petroleum is injected into the cylinder head in the form of a spray, spontaneous ignition and expansion occurs, and the piston is driven forward. Instead of an explosion, a prolonged combustion takes place during the full stroke. On the following exhaust stroke the products of combustion are expelled in the usual way. The illustration depicts a small single-cylinder Diesel engine, which has overhead inlet, exhaust, oil injection and starting valves. The operation of starting is performed by compressed air. It will be noted that the air compressor is worked by a small crank alongside the main crank. The chief advantages of this engine are its very high fuel efficiency, viz., 38 per cent., the consumption at normal load being well below half-pint per b.h.p. hour, and the fact that no ignition system is required. This engine has not as yet been applied to light-car construction, but experiments are being made with it in connection with heavy traction. The weight and bulk of this type of engine are at present drawbacks, which, however, may be gradually overcome and render it more generally applicable. For marine work this engine has been largely adopted. It is also made in a two-stroke type, which is reversible in direction of rotation.

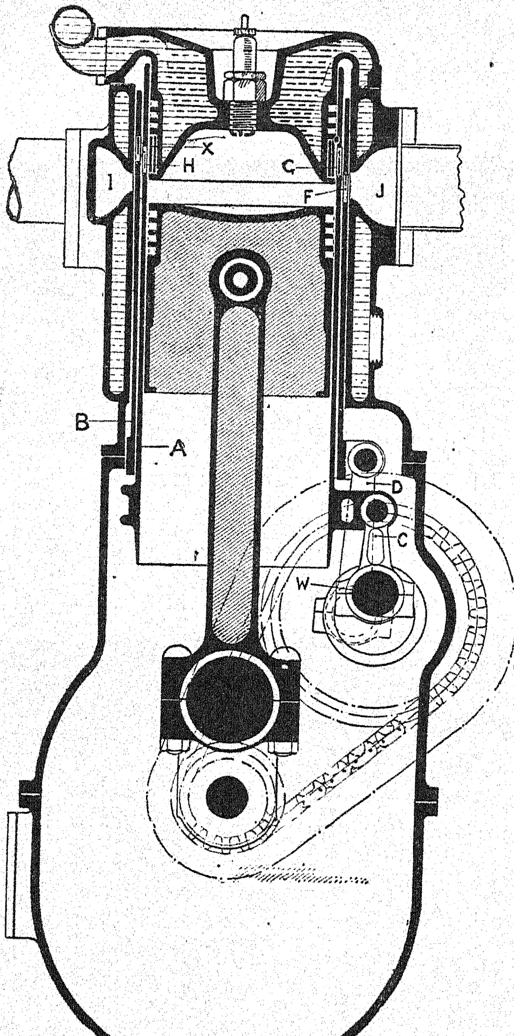
Piston-valve Engines

This type of engine came into vogue at the period several years ago when the sleeve valve made its appearance. The idea was to obtain with this type the same advantages as the sleeve valve gives, such as the smoothness of working and large valve opening-area. Several different types of piston-valve engines were introduced, but they never came into extensive use, and are now extinct. The universally-used poppet valve has been so vastly improved that it is really a difficult matter to find any alternative system, apart from the sleeve type of valve, which shows any marked advantage over it when all the factors in the question are taken into consideration. Reference, however, may be made to one existing piston-valve engine (page 22). In place of the two poppet valves for each cylinder there is a piston, working in a reduced extension of the cylinder directly over the piston heads; this valve chamber is actually the combustion chamber of the cylinders. The piston



Section of single-cylinder Diesel engine, see description on previous page.

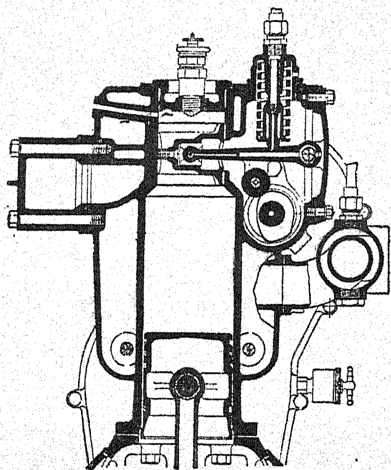
valves are actuated from a camshaft passing through a chamber alongside the combustion heads. The mechanism for each valve includes a rocking lever, which has a ball-end socketed into a sliding block in the piston valve itself. A strong helical spring bears on to the top of this lever, so as to keep the cam roller, which is mounted on the same lever, in close contact with the actuating cam. This cam is of special formation, designed to give a rapid opening and closing of the valve, with



Daimler Sleeve-valve Engine

A description of this engine appears in pages 22 and 24.

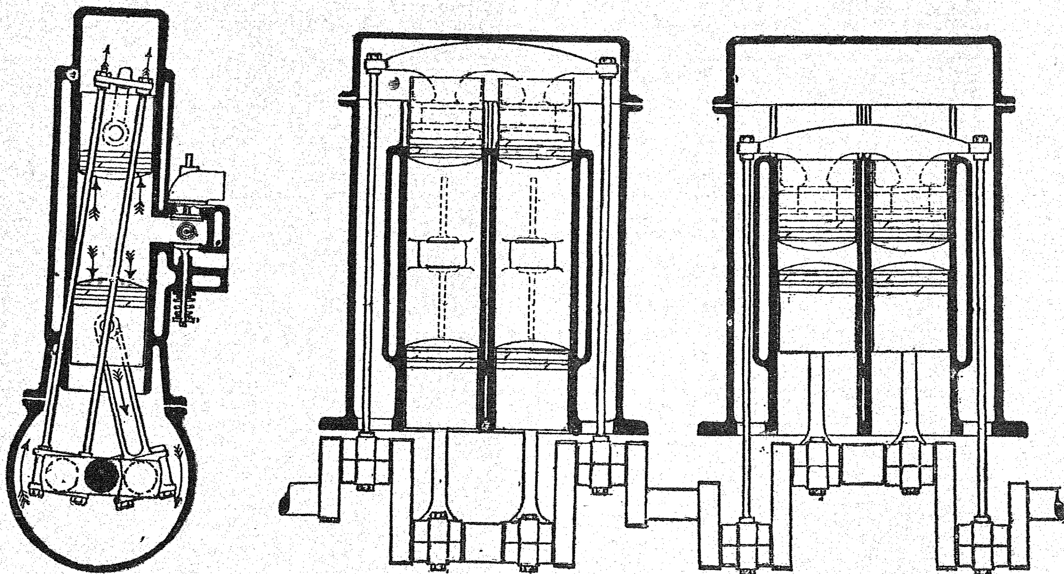
comparatively long rests at full open and closed positions. The two valve ports are, of course, uncovered in correct sequence by the one valve movement. All these valves are easily and quickly removable, and they are split like a broad piston ring so as to ensure a gastight joint over the valve ports. In plan the piston valve is open ended, so that the combustion chamber is in direct connection with the cylinder, the force of the explosion passing through the valve. The inlet and exhaust ports are cast in the combustion chamber, but these are not visible in the drawing.



Reno-Maudslay Piston-valve Engine.

Details of Daimler Sleeve-valve Engine

The cycle of operations in this engine is the same as that of the ordinary poppet-valve type. It differs in construction by the substitution of sliding valves for the usual poppet or tappet valves. The sliding valves consist of two concentric sleeves of cast-iron accurately turned, working in between the driving piston and the cylinder walls. These sleeves have two series of large area ports or slots cut in the upper ends, which register together at the required instant in the respective strokes of the piston. One pair of slots form the inlets and the other pair the exhausts. The sleeves of each cylinder, which have a relatively short stroke, about 1 in., are driven by two short connecting rods or side arms working off a lay crankshaft, the cranks having a very small throw, which takes the place of the usual camshaft in the tappet valve form of engine. This valve-operating shaft rotates at half the speed of the main crankshaft. The sleeves extend right up into the deep cone-shaped combustion head, which is a detachable unit. This head is of a special design, insomuch that it is provided with a set of piston rings, three narrow and one double, the latter being of extra width and termed the compression ring. These

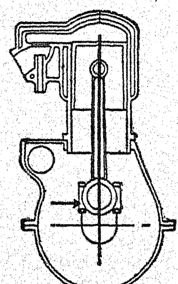


Double Piston Engine

This distinctive type of engine has been in vogue for many years and is used on the Gobron-Brillie cars. The illustration shows a four-cylinder engine; the explosion taking place between the upper and lower pistons and driving them apart. The upper piston is connected by a long driving rod which is attached to a rocker bar. There are in all eight cranks and eight pistons, and the effect of this arrangement is to produce a perfect balance of the moving parts and to avoid downward thrust on the main bearing, thus lessening the wear and tear. The explosive mixture enters by the port shown in the middle of the cylinder.

rings prevent any escape of pressure in an upward direction, whilst the usual set of three rings on the working piston maintain pressure tightness in the lower direction. A sparking plug for magneto ignition is fitted in the centre of the combustion head. The lubrication of the sleeves is effectively maintained by spiral oil-ways on the surface, and numerous holes drilled through, which direct the oil thrown up by the crank, on the usual splash principle, to the working surfaces. The working details of this engine can be readily followed by reference to the diagram on page 21 showing a vertical section. The two sleeves encircling the working piston are at A and B. At the top on left is the inlet port (I), with inlet slots (H) almost in register. Opposite is the exhaust port, with slots G and F), in the "shut" position. The short connecting rods giving sliding movement to the sleeves, by means of side lugs, are shown at D and C; whilst W is the special crankshaft off which they work. The layshaft is driven by a chain instead of the usual two-to-one gearwheels. By the elimination of the usual tappet valves a very smooth and noiseless action is obtained, and the large ports in the sleeves give the utmost freedom to the inlet and exit of the gases, resulting in an increase of flexibility. The absence of any pockets and projecting parts in the combustion chamber avoids all pre-ignition risks, and gives a very high fuel efficiency. A high compression is obtainable without risk, although, in practice, 80 lb. is not exceeded. The combustion head, it will be seen, is amply water-jacketed, the water space being self-contained and not depending on a joint. It attaches to the cylinder by a well-surfaced joint, kept in close contact by a series of bolts passing through the head into the cylinder casting. The engine is, as a whole, considerably simpler, neater in exterior appearance, and lighter than the ordinary type, and all working parts are enclosed and thoroughly lubricated. An independent supply of oil is carried direct to the lower part of the cylinder walls.

Principle of "Offset" Cylinder, or Desaxe Crankshaft Setting



By setting the crankshaft centre out of line with the cylinder centre, that is, behind the cylinder in direction of rotation, a direct thrust is obtained on the down stroke greatly lessening the side pressure on the cylinder walls. The angularity of the connecting rod is greater on the up stroke, but total thrust pressure lessened. This reduces the wear and tear on the cylinder bore.

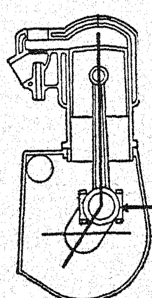
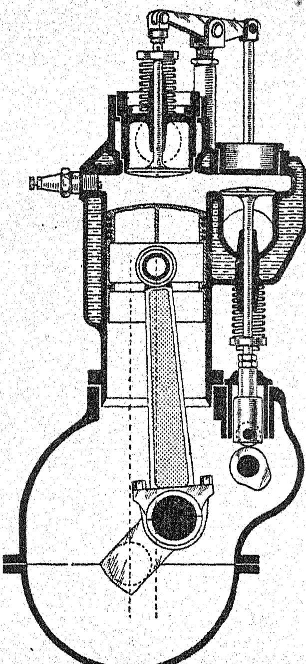


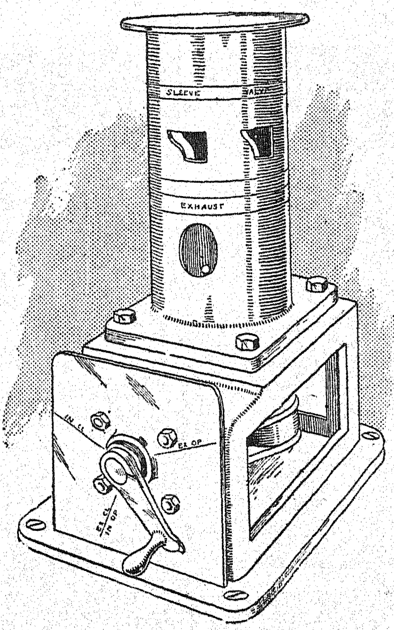
Diagram of usual or symmetrical crank setting.

Diagram of engine with offset cylinder.



Overhead Inlet Valve Type of Engine, with Offset Cylinder

Illustration of a Desaxe type of engine (the two vertical broken lines showing the amount by which the crank shaft and axis of cylinder are offset). It also shows the arrangement of an overhead system of inlet valve operated by rocker and tappet rod. The valve is of large diameter which is now the standard practice.

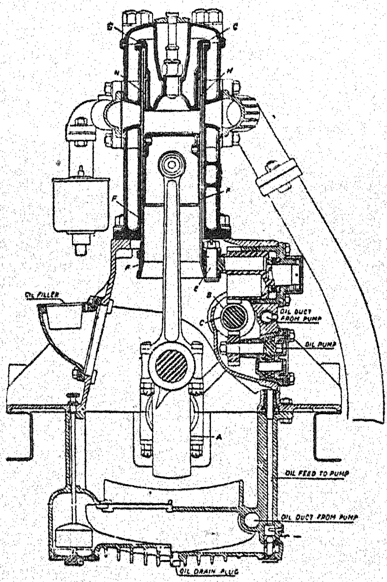


Single Sleeve Type of Engine

Diagram of a model illustrating the working of Argyll single sleeve valve. The special shape of the ports in the cylinder, which are being closed by the movement of the interior sleeve, will be noted. A diagram illustrating the various phases of the valve movement s shown on page 27.

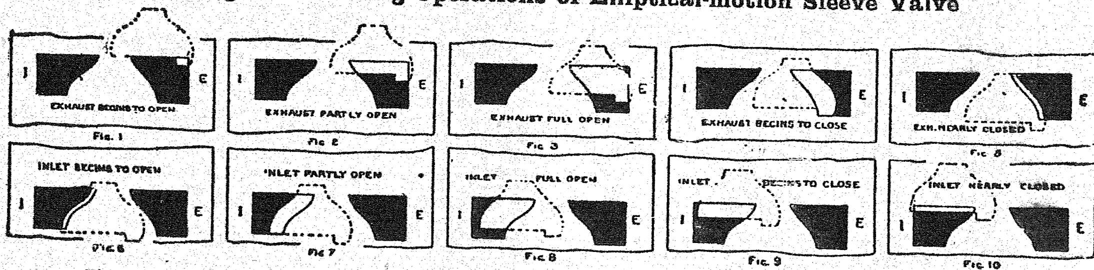
Single Sleeve Type of Engine

There are several methods of opening and closing inlet and exhaust ports in the cylinder wall by means of a single sleeve only. One of these methods depends on a simple reciprocating movement of the sleeve between the working piston and cylinder walls. An alternative method which has worked well in practice consists in giving the sleeve an elliptical movement; that is, in moving up and down it also makes a partial turn backwards and forwards. and any given point on it describes an ellipse. There are six ports provided in the cylinder: three each for the inlet and exhaust, but the oscillating sleeve has five ports only, one serving for the exhaust and inlet. The shape of these ports is peculiar, but the design has been worked out to give the greatest freedom to the flow of the gases by providing as long a period of opening as possible with quick opening and closing. The combined motion of the sleeve is obtained by a simple mechanical device. The lower end of the sleeve is provided with a pivoted bolt which can move in a horizontal plane. This bolt engages in a hole in a disc, which is driven by a worm gear. This hole is bored eccentrically, and in rotating produces the elliptical movement of the sleeve and the consequent opening and closing of the ports.

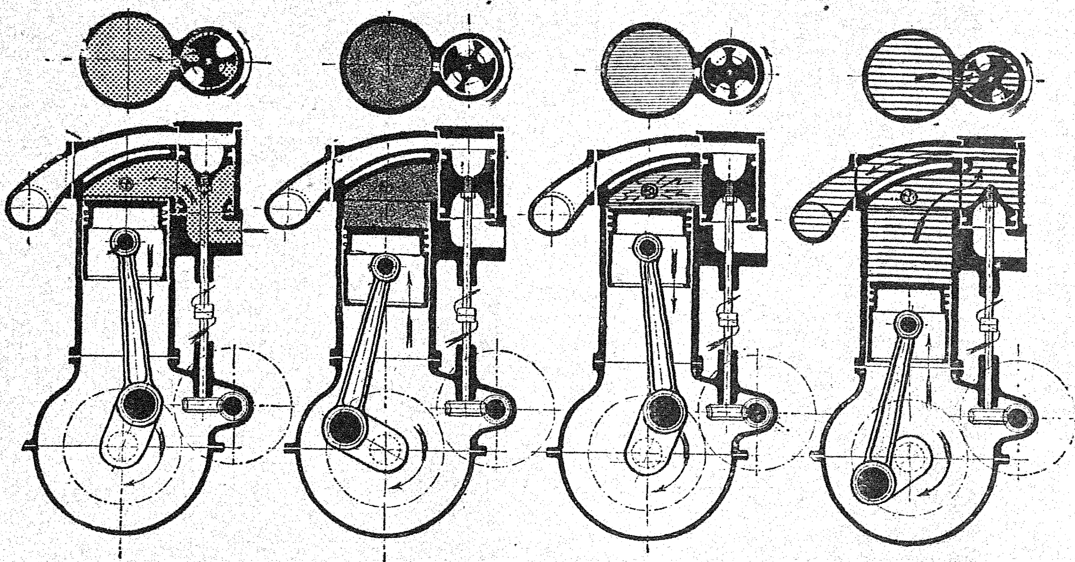


Section of Argyll single-sleeve-valve engine. The mechanism for producing the peculiar elliptical motion of the sleeve is shown on the upper right-hand side of the crank chamber.

Diagram showing Operations of Elliptical-motion Sleeve Valve



This diagram illustrates the various phases or positions of openings in the sleeve and cylinder during the inlet and exhaust strokes. The black parts represent the ports in the cylinder, and the dotted part the port in sleeve, which has an elliptical motion.



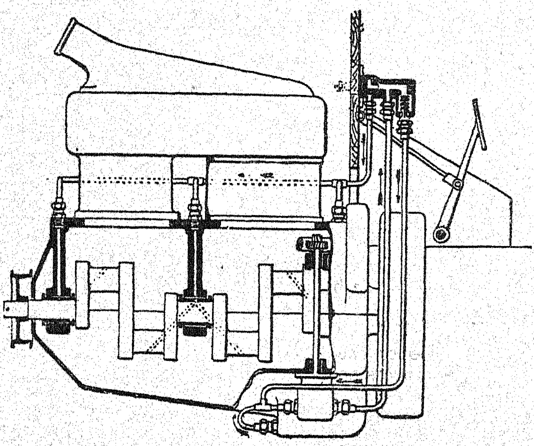
Itala Rotary Valve Engine

This illustration depicts the cycle of operations of the Itala Rotary Valve engine. Reading from left to right the operations are induction (inlet), compression, explosion, exhaust. The valve in this engine is arranged vertically, the drive being by spiral gearing. As shown in the plan and section, ports are cut in the valve which at the required moment in the cycle of operations register with ports in the cylinder. This type of valve is water cooled and the valve rotates against rings fitted in the valve chamber, which maintain it pressure tight.

CHAPTER III

Lubrication, Carburetters and Cooling Systems

The arrangements for lubricating motor mechanism are of special importance. The engine demands regular but not excessive lubrication. In the simplest and oldest arrangement the oil is injected into the crankcase at intervals, the cylinder and piston lubricating themselves on the splash principle, i.e., the end of the connecting rod dipping in the oil throws up a continuous spray into the cylinder. The oil is carried in a small tank on the dashboard of the car. A pump is combined with it, and by this means a charge can be injected into the crankcase when required. On up-to-date cars the lubrication is effected automatically by a pump driven by the engine, and, provided that the oil supply is maintained in the crankcase (or separate tank in some cases), no attention is required. It is usual to provide a "sight" on the dash, which enables the driver to regulate the amount of oil supplied to the bearings. There is considerable variation in the detail arrangements of engine lubrication, but in the system in general use the pump is placed inside the engine, whence it draws oil from a well in the bottom of the crankcase. Oil is forced up to a sight on the dashboard, and thence passes on to the bearings by a number of feed pipes. The oil from the bearings is continually draining into the well or sump and being used over and over again, and a considerable economy of oil is thereby effected. A method, used on most of the large, expensive cars, is by high-pressure force feed to each bearing. The crankshaft is drilled throughout its length, and the oil forced through the channel thus formed, issuing at each bearing through an aperture and lubricating the bearings from the inside. A small pipe carries oil up each



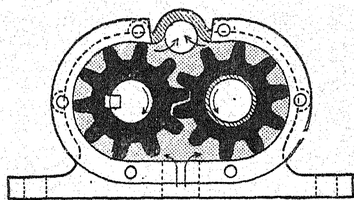
Automatic lubrication system for a four-cylinder engine. A rotary pump is mounted at the lowest part of the crank chamber and delivers oil at pressure via a sight on the dash to the engine bearings through the pipes and drilled crankshaft as indicated by the arrows and dotted lines. The oil drains off again into the well at the lowest part of crankcase and supplies the pump continuously.

connecting rod from the "big ends," and distributes oil to the gudgeon pins, and thence to the cylinder walls.

The lubrication of the cylinder walls is effected in most instances by "splash," that is by the oil thrown up more or less in the form of spray by the connecting rod big ends. These either dip directly into the oil, which is contained in the crankcase base in a series of troughs, or the end of each connecting rod is provided with a small metal extension, named a "scoop," which dips into the oil at each stroke.

Pump Construction and Arrangement

Oil-circulating pumps consist of two classes: the rotary and the plunger or piston type. There are many modifications in design, but in general principle there is not much variation. The plunger type embodies a cylinder of very small bore, in which a steel plunger works up and down, the motion being obtained by an eccentric taking its drive from the engine valve camshaft or other convenient part by



Gear wheel type of lubricating pump.

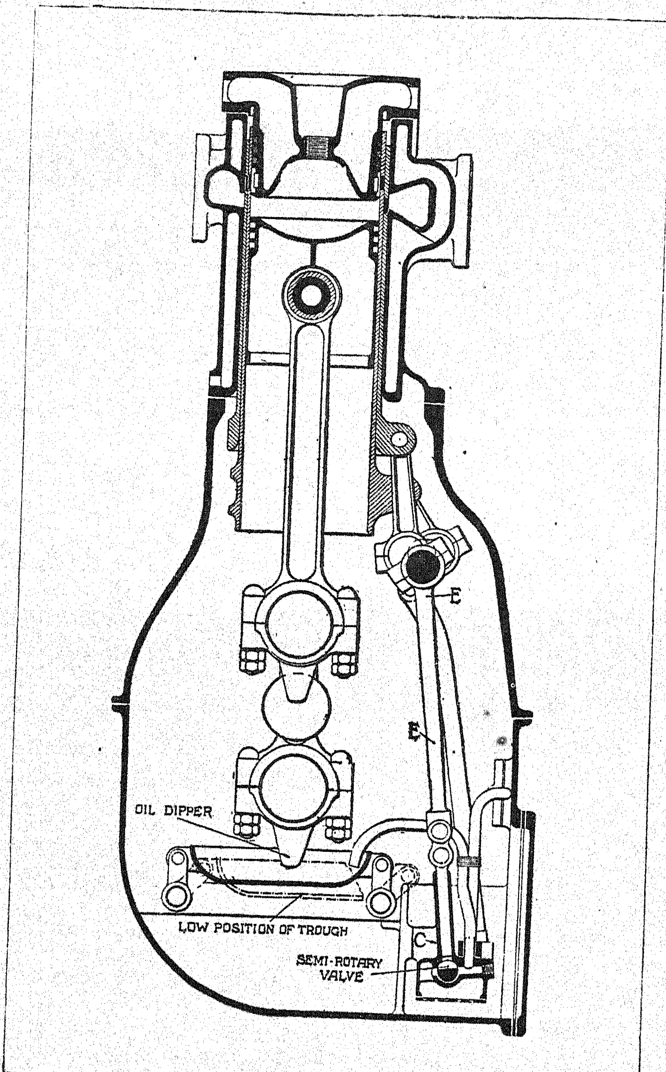
means of a simple pinion gear. The inlet and outlet valves of the pump are of the simple ball type. The rotary or cogwheel pump consists of two small pinions, which engage one another, and running in a closely-fitting casing. Oil enters at the lower part of the casing at the midway position, and leaves at the top. The actual transmission of the oil is effected by the spaces in between the teeth, each forming a sort of pocket for a small charge of oil. The oil is carried round both sides of the casing, the teeth at the point of engagement at the centre forming an oil lock. (This form of pump is illustrated above, and a piston pump is shown in the engine diagram, page 31.)

Filtering and Cooling the Oil

Special care has to be taken to ensure that the oil passing to the various bearings is perfectly free from foreign matter, such as grit or particles of carbon deposit which would cause damage to the bearings. For this reason the oil which drains back into the "sump" is strained or filtered through fine wire gauze. On some engines a gauze strainer is fitted in the filler so that the oil is strained previous to entering the crankcase. It is the practice on some cars to provide cooling ribs or flanges on the lower part of the crankcase, wherein the oil is contained. This, to some extent, cools the oil and improves its lubricating properties before it is pumped back to the bearings.

Quality of Oil to Use

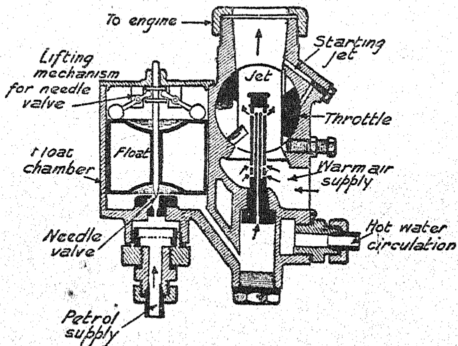
Engine oil must always be of the grade adapted to the work. A large number of oil manufacturers specialize in engine oil. The qualities of a suitable oil are, briefly, ability to retain its lubricating property when heated, it must produce very little deposit of carbon, and it must be free from any foreign agent, such as acid, which would attack the metal it comes in contact with.



Lubrication system adopted on the Daimler sleeve-valve engine in which a "dipper" at the end of each connecting rod throws up oil on to the sleeves and piston. The trough is kept charged with oil by means of a pump operated by the long connecting rod E. The oil continually drains back into the well in which the pump works.

Carburation and Carburetters

To obtain energy from petrol or other easily volatile fuel, it is necessary to convert it into a vapour and mix it with a large volume of air before it can be exploded in the cylinder. The method of producing this explosive mixture is to "spray" the petrol through a fine nozzle or jet into a vaporizing or "mixing" chamber, into which air can be drawn to intermingle with the vapour. The spraying is effected by the strong suction caused during the induction stroke of the motor acting directly on the jet. The device in which this operation is performed is termed a *carburetter,* and the operation itself is known as *carburation,* from the fact that petrol largely consists of carbon. Petrol is one of the "hydrocarbon" series of compounds, and has the formula C_6 H_{14}, i.e., carbon and hydrogen in definite proportions. The best explosive proportions of gas to air range from 1 to 18 to 1 to 20. The percentage of petrol vapour in the theoretical best mixture is 1.88, using a spirit of .720 specific gravity. Petrol vapour is three times as heavy as dry air. It must be remembered, in considering explosive mixtures, that air is a mixture of, approximately, one part of oxygen to four parts of nitrogen by volume, the latter being an inert gas, only the oxygen combines with the petrol. The products of combustion, or the "exhaust" consist of water in the form of steam carbon dioxide gas and nitrogen gas.



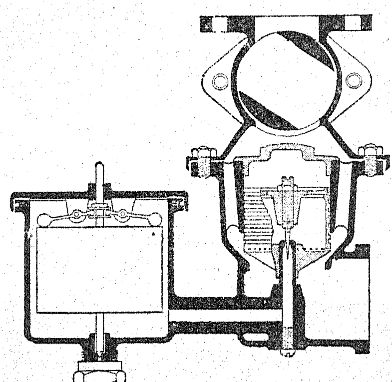
Simple carburetter The principal features of a standard carburetter are shown here. In this particular type the warm air circulates round the jet as shown by the arrows. When the float rises to the proper height, it causes the two pivoted arms to force the needle valve on its seat, and thus shut off the petrol.

Principle of a Carburetter

Although there are scores of different types of carburetters, the following description refers to the important features of the majority of them. There are two chambers, one containing a metal float, which controls the amount of petrol entering through the passage below. When the float sinks it opens a small valve and allows the petrol to flow in till a certain level is reached. The float then rises and closes the valve. In the second chamber is a jet communicating with the float chamber. The petrol should just reach to the top of the jet. Surrounding the jet is a constricted tube known as the "choke tube," which intensifies the suction on the jet. This tube communicates direct to the atmosphere through the right-angled passage below.

When the suction of the engine occurs petrol issues through the jet, and an inrush of air comes from below and passes upwards, carrying the sprayed petrol with it, and thus forming the explosive mixture. Many carburetters now have an auxiliary jet, which comes into action when the throttle is nearly closed, to enable sufficient petrol to enter the inlet pipe to form a rich enough mixture when the engine suction is diminished. There is an annular space around the spraying chamber, the purpose of this being to act as a "hot jacket." Hot water from the cooling system circulates through this chamber and prevents the carburetter becoming too cold, as it would do otherwise, as heat is extracted from the metal by the act of vaporization of the petrol. Without extra heat the chamber would in cold weather freeze up owing to the moisture usually existing in the atmosphere being converted into frost.

The main air inlet to the carburetter is usually placed close to the exhaust pipe near the cylinder, so that the air supply is warmed before it comes into contact with the fuel.



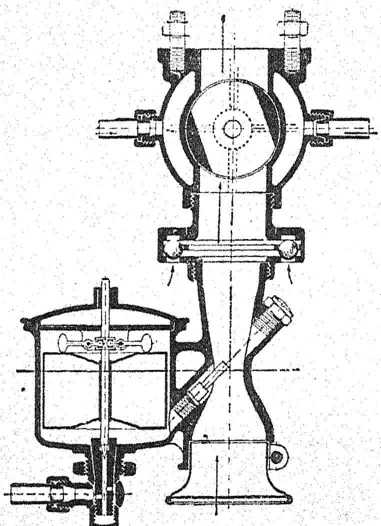
Example of a variable jet carburetter the principle of which is that the petrol jet and air supply are controlled simultaneously by the suction effect of the engine. The jet is regulated by a taper needle which is attached to a piston which is lifted by the suction effect. The petrol sprays out of the small holes in the lower part of the hollow piston and there meets the inrushing stream of air which is similarly controlled in volume by the piston, the higher it lifts the greater the air supply that can pass round the annular space.

Motor Fuels

Petrol, motor spirit or gasolene are names given to a product obtained from heavy petroleum by a process termed fractional distillation. It is a light, easily volatile liquid, with a characteristic odour. This spirit has the property of vaporizing at ordinary temperatures and pressure, and when mixed with air in about the proportion of 18 parts to 1 of petrol vapour forms an explosive mixture, which can be readily ignited by an electric spark. The density of petrol nowadays is greater than it was, from a specific gravity of .680 it has risen to as high as .730, although the average is about .710. The specific gravity or relative density is not now regarded as a comparative test of the quality of a given sample of spirit. The present day heavy grades give, if anything, a greater amount of energy per gallon than the former light spirits.

Treatment of Fuels: Paraffin: Benzole

To produce an explosive mixture of paraffin and air a special form of carburetter is required. If paraffin is used in any standard carburetter as made for petrol, very inferior, if any results at all, will be obtained. The paraffin will condense in the inlet pipe, and little, if any, vapour reach the cylinder. Considerable heat is required for proper vaporization of paraffin, and carburetters for this fuel are specially arranged for exhaust-jacketing. The paraffin, for instance, may pass through a spiral tube inside a casing carrying exhaust gases;



An example of an automatic carburetter. The main supply of air enters from below the cone shaped "choke" tube. The auxiliary air supply enters through the seatings of the small ball valves at the top of the choke tube. The upper part of the carburetter comprises the throttle valve, shown nearly fully open. This part of the carburetter is jacketed for a hot water supply.

the vaporizing chamber would also be heated. For starting up petrol would be used, a by-pass being provided to a small tank containing petrol. Any carburetter for use with paraffin must be placed as close up to the motor as possible, and the inlet piping should be short and free from bends. Ample provision for extra air should be provided, as incomplete combustion of the paraffin has a serious effect on the valves and plugs, etc., resulting in fouling and heavy deposits of carbon, causing pre-ignition. The exhaust from incomplete combustion of paraffin is also very smoky and odorous.

Benzole

This fuel is now recognized as the most practical alternative to petrol. It is well known that "The Motor" has done important pioneer work in making the advantages of benzole widely known amongst motorists, with the result that the demand and output are increasing at a rapid rate. Being a home-produced fuel based on the distillation of coal, the desirability of increasing the supplies is obvious. The factor in the successful use of benzole on a car is that the spirit shall be of good quality. An unwashed, or insufficiently

washed, spirit cannot prove successful, and a diluted spirit with an excess of, for instance, solvent spirit is not likely to prove altogether satisfactory, whilst too much sulphur in the fuel will prove obnoxious from the point of view of the smell from the exhaust gases, and in some cases if the presence of the sulphur is excessive, chemical action might take place on some of the copper portions of the carburetter, if any. This is owing to the fact that the chemical compounds of sulphur in benzole are more easily decomposed by the presence of copper than are the sulphur contents in petrol. If the benzole is of good quality the engine will run just as well, and generally better than with petrol, and also keep just as clean, or even cleaner.

Carburetter Adjustment

The question of the carburetter comes into consideration now, and many types will run quite well without any alteration at all. If the carburetter setting is right for an average petrol use, then the jet orifice should be reduced about 10 to 12 per cent. before using benzole. Then again, the spirit being heavier than petrol, the float has to be weighted in order to maintain the same level in the float chamber and the jet. In some carburetters this matter is of but little import, but on the other hand it may be a necessary factor in other carburetters. The difference is, roughly, 17 per cent., so that the float can be weighed, and a weight equivalent to the difference put upon it. A still rougher method, and one which is usually sufficiently near actual accuracy for average employment, is to put upon the float a little solder equivalent to something between the weight of a farthing and a halfpenny. It is usually preferable when adjusting the carburetter to do so on the lines now laid down, rather than to endeavour to utilize the same jet orifice, whilst adding more air. Having made these simple adjustments, see that the engine is clean, and then examine a plug cap after, say, a 50-mile run, and if there is any sign of sooting, it means that the jet orifice should be very slightly reduced further. It will generally be found, however, that something in the nature of 10 per cent. reduction in area will "hit the mark."

Benzole as a Solvent

It must be remembered that benzole, generally speaking, is a stronger solvent than petrol, and that some benzoles are particularly strong, consequently, if there should be any paint inside the tank, small pieces of rubber, etc., which have been innocuous while petrol has been used, it is conceivable that these may now become dissolved and carried to the jet. If a tank should be found to be thus dirty, it should be filled with benzole and left for a time, and then the whole run off, and with a little swilling and shaking it can usually be cleaned out. The benzole can be carefully strained and then, of course, used. It is as well to guard against spilling benzole on the paintwork or varnish of a car.

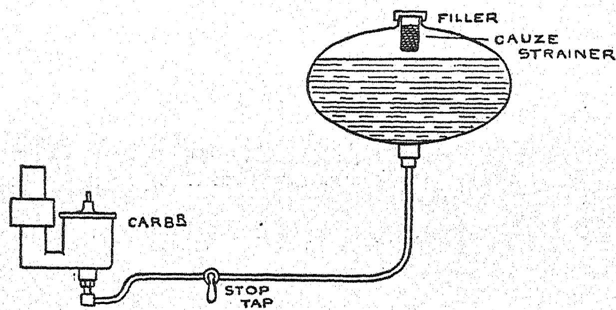
The Question of Compression

The question is sometimes asked if it would be desirable to put compression plates on to the top of the pistons to increase the compression. Admittedly an engine running on benzole will stand a higher compression without knocking, and it is probable that a slightly better efficiency would be obtained, but it is certainly not advisable to do this in the present state of affairs. Correlatively to the question of compression is the fact that it seems practically impossible to make an engine knock on benzole, and in a large number of cases which have

been related an engine which knocked at the slightest hill on petrol absolutely gave up this misbehaviour on using benzole. Heating the carburetter and induction pipes, especially the latter, is advisable with all carburetters, as heating is requisite before the atomized fuel can be turned into a true gas, and it is preferable to do it en route than to wait until the charge reaches the combustion chamber. With benzole the heating is in some cases slightly more desirable, and sometimes a small auxiliary pipe from the water-circulating system can conveniently be coiled around the induction pipe.

Cause of a Flooding Carburetter

A persistent tendency to flood, no matter how carefully the needle valve may be ground in, will often be found to be due to a punctured float, and as the petrol can get through practically anything in the shape of a crack or pin-hole, the buoyancy of the float is at once altered. Examination of the usual type of float will show that it consists of two halves soldered together, with a tubular centre soldered top and bottom. These are the places where leakages are liable to occur. If a crack or puncture is discovered—and it often necessitates very careful inspection—it is only necessary to dry out the petrol in a current of warm air and re-solder, taking special care that the weight is not increased.



Method of obtaining a gravity supply of petrol to carburetter. The petrol tank is placed at a higher level than the carburetter. Some small cars have a combined tank and dashboard.

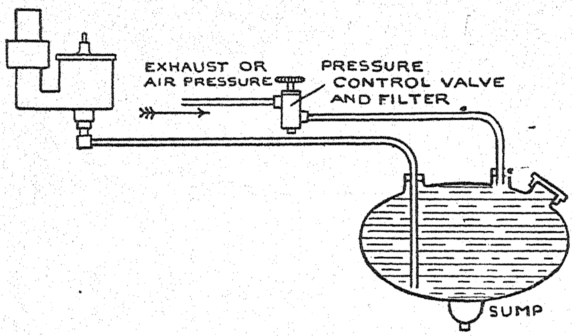
Gravity and Pressure-Fed Petrol Supply

These are the two systems of petrol supply in vogue, the pressure-fed being mainly used on large cars, in which a petrol tank of large capacity is fitted to the rear. To raise the spirit from the tank level up to the carburetter a connection is made between the tank and exhaust pipe, or from a small air pressure reservoir charged by an automatic pump, the pressure thus obtained forcing the petrol into the carburetter. An intercepting valve on the pressure pipe prevents, as far as possible, the ingress of moisture and overheated gas into the petrol tank. For starting purposes some cars have a small auxiliary gravity tank joined by a two-way tap to the carburetter; usually a hand pump is fitted to raise the initial pressure in the tank. The gravity system

is the simpler, the tank being fitted under the seating space or at the rear behind the body. In some cases it forms part of the dashboard. This is a plan often adopted on small cars, as it economizes space. (See illustrations on previous page and below.)

Petrol Filter

It is important that the petrol in the tank be quite free from water and foreign matter. The tank should always be filled through a funnel fitted with a strainer of the finest gauze to intercept water or grit. An additional filtering and water trap device should be fitted between the tank and carburetter. This must be cleaned out occasionally.

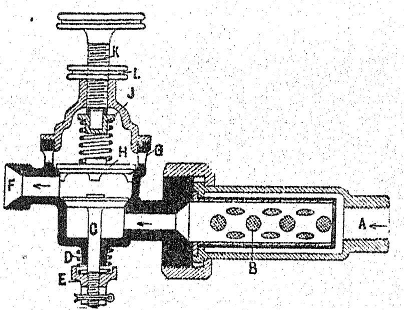


Pressure supply system; the tank being below carburetter level, and the petrol raised up to it by pressure from the exhaust or from an air pump. A gauge (not shown) indicates the amount of pressure in the tank. For starting up, initial pressure in the tank is obtained from a hand pump. This system is used on many large cars which require a large petrol supply. The tank is fitted at the rear of the car. The "sump" is a form of well which serves as a trap for grit and water. It can be drained by unscrewing a nut.

The Handling and Storage of Petrol

Owing to the highly inflammable nature of petrol spirit particular care is required in the handling and storage of it. There are certain Board of Trade Regulations to be observed with regard to it. Thus the spirit must be kept in metal vessels not exceeding two gallons capacity, fitted with screw stoppers, so that no leakage can take place. Not more than 60 gallons may be stored in one place or at any one time. This is exclusive of any quantity of petrol stored in the tank of the car. Any person keeping petroleum spirit in a storehouse situated within 20 feet of any other building, whether or not in his occupation, or of any timber stack or other inflammable goods, must give notice of same to the local authority under the Petroleum Acts for the district. This regulation does not apply to petrol kept in the tank of a car. If it is desired to keep petrol for sale, a licence from the local authority must be obtained. The safest plan for storing any quantity of spirit is to keep the cans or vessels in an underground concrete or metal chamber, some distance away from any building or outhouse. *It is of the utmost importance that petrol should never be handled in the vicinity of any gas, oil, or candle flame.* Neglect of this rule has been the cause of a number of serious and fatal accidents. Petrol may be safely handled by electric incandescent light; but even in this case it is desirable to have the electric bulb protected by an outer glass cover. In the event of a petrol fire occurring, instant steps

should be taken to get a large quantity of sand or damp earth, which can be thrown on the blazing spirit with the object of absorbing it and extinguishing it, or one of the patent "extincteurs" sold may be used. A small fire can be extinguished by smothering it with a damp cloth.



Section of pressure control valve and filter.

A Exhaust connection.
B Gauze filter.
C Pressure supply valve.
D Spring to C.
E Pressure regulating nut.
F Connection to petrol tank.
G Escape ports.
H Pressure relief valve.
J Spring to H.
K Relief pressure regulating valve screw.
L Lock-nut to K.

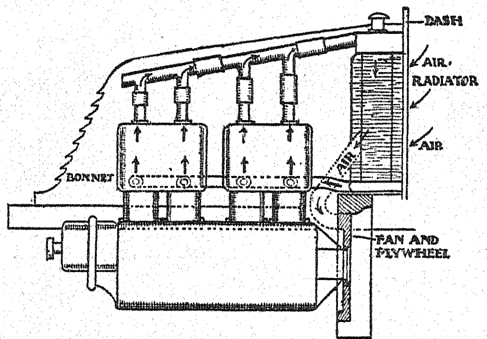
WATER-COOLING SYSTEM

To maintain the engine at a workable temperature, water-cooling is adopted. This is effected by causing water to circulate continuously around the cylinders by natural or thermo circulation, or it may be forced round by a rotary pump. The heated water from the cylinders returns through a radiator, in which it passes through a series of thin copper tubes, which have radiating webs or flanges of thin metal surrounding them. The object of the flanges is to dissipate as much as possible of the heat absorbed by the water by exposing it to a large cooling surface of metal. The radiator system is usually fixed in the forward part of the car, to obtain the full benefit of the draught of air. The same water is used continuously, so that it is only necessary to replace the loss caused by evaporation. It is usual to have a rotary fan to assist in inducing a draught of cold air through the radiators and accelerating the cooling when the car is moving slowly, as in hill-climbing or slow running in traffic. The fan is driven from the crankshaft by a belt and fixed at the back of the radiator. An alternative method which avoids the use of a separate fan is the provision of fan-vaned arms in the flywheel.

Thermo Circulation

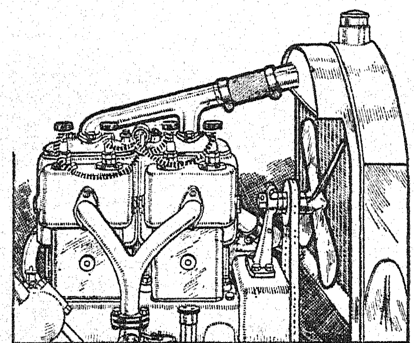
The principle known as "thermo circulation" has the merit of simplicity. The flow results from the difference in density between heated and cold water. The cold water flows out of the radiator into the lower part of the cylinder jacket. The heated water rises up through the top of the jacket by reason of being lighter, and then re-enters the radiator; as it comes into contact with the large cooling area it becomes denser, and flows out again and re-enters the cylinders. The efficiency

of a natural circulation system mainly depends on the pipes being of large diameter, short and free from bends, to offer the least possible resistance to the flow. The upper part of the radiator where the water enters must be well above the tops of the cylinders.



Cooling by thermo-syphon circulation. (Radiator behind the engine.) Pump dispensed with. The arms of the fly-wheel are designed to act as fan-blades; a separate fan is unnecessary, but the underpart of the engine must be carefully screened in.

In the type of engine in which the cylinders are cast together or "en bloc" a single cooling jacket embracing the four cylinders is used. Baffle plates to direct the circulation of the water round the valve pockets are fitted inside.



An example of a thermo-syphon system cooled engine in which a belt-driven fan behind the radiator is used to draw air through it. This system is now practically standard, the pump being used on a minority of engines.

The upper diagram is typical of the cooling system on many cars, as the placing of the radiator to the rear provides accessibility to the engine, magneto, etc.

CHAPTER IV

Ignition Systems

Many readers of this book are familiar with the meanings of the electrical terms employed in the following pages. On the other hand, there are probably many others who are entirely unversed in the technical phraseology of electricity and magnetism. For their benefit the following list of explanations has been drawn up.

Definition of Terms Relating to Electrical Ignition Systems

Electric ignition refers to any method in which the explosive mixture of petrol vapour and air is fired by an electric spark.

Magneto ignition or magneto electric ignition express the same, namely, that the electric current causing the spark is produced primarily from magnets and rotating coils of wire forming the armature, these being the fundamental parts of a dynamo. The generation of the spark is thus effected automatically by the engine driving the magneto.

Coil and battery system of ignition.—In a battery the electricity is obtained by *chemical* means instead of mechanical means, as when a magneto is used. The coil has *nothing to do with the generation of the* electric current, its function being to " gear up," intensify, or increase the pressure or transform the low-voltage primary current generated by the battery into a high-voltage secondary current to enable a spark to be produced across the air gap of the sparking-plug points.

Accumulators.—Secondary battery, or storage battery.—The electricity produced from a dynamo can be readily converted into chemical energy, and this can be stored up in an accumulator and changed back into electricity instantly when desired. It is a mistake (in a technical sense) to speak of an accumulator being "charged with electricity." Certain chemical changes occur in the elements of the cell when current is sent into it, and these create a current again through another series of changes.

High tension and low tension imply much the same meaning as when speaking of steam or water at high or low pressure. A magneto generates primarily a low-tension current, which the secondary winding on the armature converts into high-tension current. A battery or accumulator only gives a current at low pressure which is not sufficient to produce a spark, but by sending the low-tension current through an induction or intensifying coil the tension or pressure can be greatly increased so as to readily produce a spark.

Volts.—A term or unit indicating the pressure value of the current. For example, the pressure or voltage of an accumulator is 2 volts for each cell. The pressure of the sparking current may be as high as 20,000 volts. It is a unit comparable to the pounds per square inch used when speaking of steam or water pressure.

Amperes defines the rate of flow of current along the wires as distinguished from the pressure forcing it along. It is a unit that may

be compared with the gallons per minute unit used when dealing with hydraulic measurement.

Ampere-hours capacity of an accumulator is a term used to express the amount of electrical energy that can be got out of an accumulator of a given size. An actual 50 ampere-hour accumulator should be capable of giving 1 ampere for 50 hours or 2 amperes for 25 hours; but the capacity tends to become less as a higher rate of current is taken from the cell.

Watts.—The unit of electrical power obtained by multiplying volts by amperes flowing in a circuit. 746 watts equal 1 horse-power. The term is much used in electric lighting. One watt should give one candle-power. The kilo-watt, which is the commercial unit, is equal to 1000 watts.

Insulator.—A material through which electricity cannot flow, for instance, porcelain, mica, india-rubber, fibre, vulcanite, glass, celluloid, paraffin-wax, silk, shellac, steatite, slate.

Conductor.—A material along which electricity will readily flow, such as copper, platinum, steel, and, in fact, all metals. Silver is the best conductor, but copper is only very slightly inferior. Carbon is a non-metallic element, but an excellent conductor much used in magneto construction for the brushes. The wires or cables of the ignition circuit are sometimes referred to as conductors or "leads."

Primary coil.—The winding of an induction coil through which the current from the battery circulates. In a high-tension magneto also a primary and secondary winding are used, the former inducing a high-voltage current in the secondary.

Secondary coil.—The winding in which the high-tension current is generated, which is quite distinct from the primary current.

Positive pole.—Usually indicated with a plus sign +, means the positive terminal, or wire from which the current starts in an accumulator or dynamo. The carbon in a primary or dry battery is positive.

Negative pole.—Minus sign, −. The point to which the current returns after passing through the circuit.

Earth connection, or "return."—An inaccurate term when applied to the electric circuits of a motorcar. The motor is insulated from the road by the tyres, hence the "earth" is not used at all. What is meant is that the framework of the car is used as a return conductor so as to dispense with some of the wires.

Commutator.—Also a term often misapplied in motor work. A commutator is really a piece of mechanism that reverses the direction in which the current is flowing. *The contact maker* is what is generally meant. A commutator is, however, an important part of a lighting dynamo from which the current is collected.

Distributor.—Used on a magneto or single-coil system to fire several cylinders in succession. A special form of rotary switch which directs the high-voltage current to the various sparking-plugs.

Condenser.—An important part in a spark coil or high-tension magneto, consisting of a series of waxed paper or mica sheets interleaved with tinfoil. Its function is to absorb the "back" or reverse current generated in the winding, which, unless passed into the condenser, would greatly lessen the sparking efficiency.

Spark gap.—A safety device on a magneto to prevent the armature windings being strained or short-circuited owing to a faulty sparking plug or wiring circuit.

Short circuit.—This expresses what takes place when the current flows along an unintentional and shorter path, which is usually a path of much lower resistance than the normal one. The current therefore fails to perform the function it ought to. If two wires carrying the

current to light a lamp come into accidental contact, the current will immediately take the shorter and easier path, and the lamp will fail to light till the short-circuit is removed.

Continuous or direct current.—This implies that the current flows in one direction from the positive to the negative terminal of the generator.

Alternating current.—A current changing its direction of flow, or "alternating," backwards and forwards. The number of alternations per second is known as the periodicity, thus, "a periodicity of 50" means 50 alternations per second. The effects of alternating current are different to those of continuous, and it cannot charge accumulators.

Ammeter.—An instrument to indicate amperes or rate of current flow, as usually fitted to the switchboard of a lighting set.

Voltmeter.—An instrument to indicate volts or pressure of current.

Synchronization.—To time two or more sparks to occur exactly at the same instant or at a similar period in a given cycle of operations, i.e., the ignition of a four-cylinder engine must be synchronized so that one cylinder does not fire relatively later than another.

Ignition of the Explosive Charge. Some General Considerations

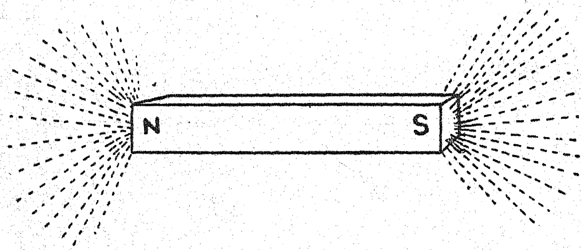
At one time this was a most difficult problem to solve. Nowadays the ignition system of a car gives practically no trouble, as a standardized system has been arrived at, viz., the magneto which generates an electric current and produces a spark automatically when required. The magneto is permanently driven by the engine. The first ignition system used on car engines was known as "tube" ignition. In this system a small platinum tube screwed into the combustion chamber had to be kept incandescent by means of a spirit burner. It was dangerous and unreliable. This system in a few years gave place to electric ignition, produced from a battery and coil, and this was much more satisfactory than the earlier tube ignition. The engine gave more power because the ignition could be timed to occur at the most effective moment in the stroke of the engine, and it was safe and also reliable so long as the batteries generated current.

This system, though obsolete, is in use on some of the older cars on the roads, and for this reason a brief description of the various parts of the system is given in another section. It will be noted, however, that it is a complex arrangement of various parts; whereas the magneto is an entirely self-contained ignition system, very compact and absolutely reliable. Its efficiency also is unquestionably greater than the coil and battery system, and for two chief reasons, the timing of the explosion of the charges in the four or six-cylinder of a modern car engine is practically perfect, and therefore, other factors being equal, each cylinder will generate equal power. With coil ignition the timing is always a doubtful quantity. The magneto also generates a peculiarly intense spark, which tends to increase in intensity with the speed of the engine—a valuable feature, as there is practically no delay in the ignition of the charge, so that the accuracy of timing is just as great at high as at low speeds. The magneto does not require any attention except at long intervals. On the other hand, the coil system, with its several component parts, requires regular attention to keep it in adjustment.

Early Magneto Systems

Two modifications of the magneto system may be briefly referred to, although, nowadays, these are of little more than historical interest. These are the original low-tension magneto and the special low-tension

magneto sparking-plug systems. The former had for some years a considerable vogue. The magneto was of the simplest type possible, but the sparking plugs, which were indispensable to work this system, were of relatively complex construction, consisting of tappets, springs,



Diagrammatic view of direction of "lines of force" issuing from north and south poles of a bar magnet, and as would be mapped out by iron filings as described. (The complete path of the lines from N to S is not shown, but the lines extend in curves from pole to pole.)

cams and other parts. The engine had to be specially designed with the tappet arrangement in the cylinders. Practically all these engines with low-tension magneto have been converted to the standard high-tension. The special magnetic plug system never came into extensive

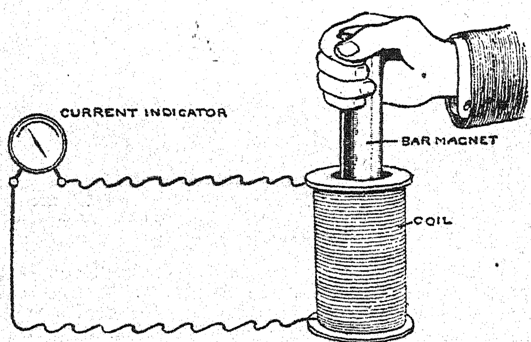


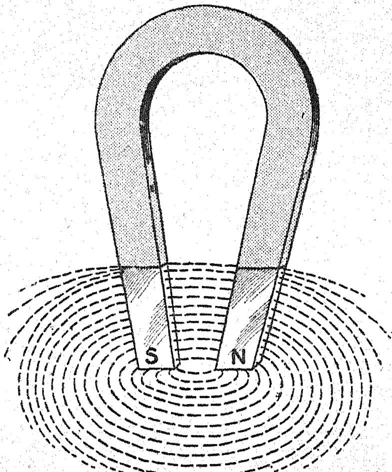
Diagram of the simplest form of magneto, which clearly illustrates the fundamental principle on which a magneto works. A magnetized bar of steel has been suddenly plunged into the interior of the coil of copper wire. A momentary swing of the needle of the current indicator proves that a sudden wave of current has been generated in the coil. On suddenly withdrawing the magnet from the coil the needle of the indicator would swing over in the other direction, showing that another wave of current flowing in the opposite direction had been generated in the coil.

use, although in some respects it was an improvement on the mechanical or tappet arrangement.

The Production of an Electric Current

There are many ways of producing electricity; for example, by chemical action, as by placing a piece of zinc and copper in salt water or acid; or by friction, an interesting practical example of

which is to be found in the static X-Ray machines. A current can be got by heating two pieces of metal, each of a different kind, thus forming a "thermo-pile," although the current is too feeble to be of practical service. The most practical of all methods is to get the current direct from mechanical energy, the means adopted to obtain current for railways, tramways, power, light and all industrial purposes. The changing of mechanical energy into electricity is possible by means of a machine termed a dynamo. Fundamentally this consists of (1) a set of magnets; (2) a series of coils of insulated copper wire so arranged that they can be revolved within the "field of force" of the magnets—this part is termed an armature; (3) a set of springs, brushes,



Lines of force around poles of a horse-shoe magnet. This diagram indicates very approximately the path of the lines adjacent to the poles as would be mapped out by iron filings.

or collectors forming a permanent connection to the coils of wire, enabling the current generated to be drawn off. The features, then, of any dynamo are its magnets and rotating coils of wire on the armature; and the distinctive term "magneto" ignition is applied because of the fact that magnets are used in the apparatus.

Simple Theory of Magneto: "Lines of Force"

The magnets of a magneto are made of a special grade of steel, made flint-hard, and are technically termed *permanent* magnets, because there is a continuous flow of magnetic force from the ends or poles. A simple experiment can be recommended as a means of obtaining a clear idea of lines of force. Buy for a few pence a small horse-shoe magnet of the ordinary kind, as sold at tool shops, etc., then obtain as much iron filings as will go on a sixpenny-piece, and a half sheet of smooth note-paper: with these few items it is possible to render the magnetic field of force at the magnet poles quite visible. First remove the small piece of iron from the ends of the magnet (it is called the keeper); place the magnet flat on the table, and over it the note-paper: put the iron filings in a piece of muslin, and sift them gently on to the paper so that they collect

near the end of the magnet; then tap the paper carefully with a pencil or any light object, and it will at once be seen that the filings distribute themselves in a perfectly regular system of straight lines and curves. The filings, in fact, map out the lines of magnetic force issuing from pole to pole. This simple experiment will prove that round about a magnet there is a "field of force." Given this field of

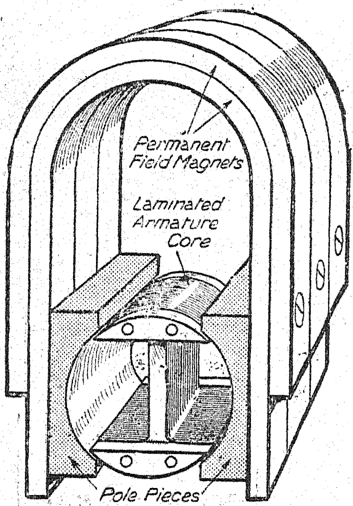


Diagram of magneto and armature "core" of a standard pattern magneto. There are three double (or compound) magnets of hardened steel. Screwed to these are "pole pieces" of soft iron. The armature core of H section is partly built up of thin iron plates the ends being solid. The channels are wound with wire, this forming the windings or coils.

force, if a closed coil of insulated copper wire be rotated within it so that the lines of force can be made to alternately pass through the coil and then be suddenly withdrawn, a current will be generated in the coil and flow along it. This current changes its direction each revolution, or "alternates." This, then, is the fundamental principle underlying the working of a magneto—viz., the rotation of a coil of wire within the field of force of a magnet.

Effect of the Armature Core

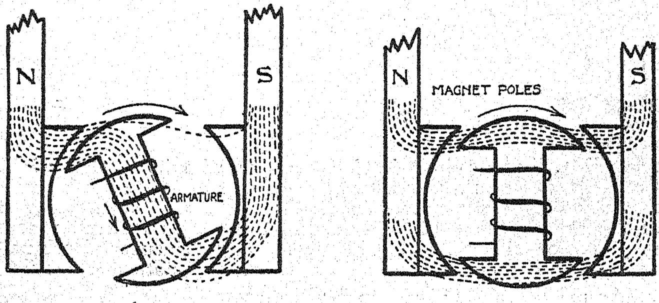
The coils of wire forming the armature of a magneto are wound on a shuttle-shaped iron core, and this plays a very important part in the generation of the current. During one period of the revolution, viz., that during which the "cheeks" or curved sides of the armature core are passing across the pole pieces or semi-circular-shaped pieces of soft iron which are screwed to the steel magnets the lines of force all pass through the coil and no change in the number of lines occurs till the cheeks of the armature reach a position which offers an easier and shorter path for the lines to get across from pole to pole. This position is that where the cheeks of the armature just bridge the space top and bottom between the magnet poles. The lines of force are suddenly withdrawn from the coil and pass directly across the iron till the armature gradually assumes its previous position and the lines of force pass through the coil again; only to be withdrawn suddenly as the armature in due course bridges the pole pieces. It is at the instant of this sudden withdrawal of the lines of force that the current is generated.

The Contact-breaker Effect

The armature consists of two distinct coils or windings: a thick-wire coil of a few turns and a very fine-wire coil of a great number of turns. The thick-wire coil is always kept on "closed or complete circuit" till the instant that the armature core is passing the position where the sudden withdrawal of the lines of force occurs. At this instant the circuit is suddenly interrupted or broken by a simple mechanical device known as a contact breaker. The effect of this sudden rupture of the circuit through which is circulating the current generated by the withdrawal of the lines of force is to greatly augment the strength of that current just for an instant.

Function of the High-tension or Secondary Winding

This is the fine-wire coil previously referred to as wound over the thick coil. It is in this coil that the actual sparking current is generated, and this occurs simultaneously with the generation of the current in the thick wire coil. The effect is one entirely of "induction" or, in a sense, the influence of the primary current. This coil is always on open circuit, being permanently interrupted by the gap at the sparking plug. The sudden rise of electric pressure in the primary causes a simultaneous rise of pressure of enormously greater force or "voltage" in the secondary winding.



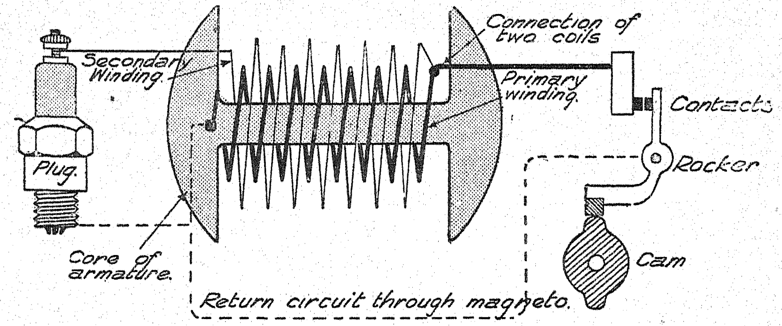
A B

Illustrating how the rotating armature alters the disposition of the lines of force. A shows all the lines threading through the coil, and on further rotating to position as B, the lines are suddenly diverted from the coil and pass through the upper and lower parts of armature. A "maximum" position occurs twice per revolution. This is the most effective position in which to interrupt the armature circuit, which results in a sudden rise of electric pressure in the armature coil.

Details of a Magneto

In any standard magneto the construction would be as follows:—The field magnets consist of two—or in large machines three—pairs, one magnet of each pair being superimposed above the others. In some few cases three magnets are placed one over the other. The magnets are set to give correct north and south polarity. The ends or poles embrace "pole pieces" of soft iron, bored out to allow the armature to rotate quite freely, but very closely to the pole faces; in some cases the clearance is only .002 in. The armature in the standard type of magneto is of the well-known

"shuttle" section. An important feature is that the armature is built up of thin stampings of soft iron, each insulated from the other by a thin film of varnish. This form of construction is known as a "laminated armature core." It has the advantage over a solid cast-iron core in that the electrical efficiency is higher by minimizing induced currents in the iron core, which represent considerable waste of energy and cause heating. By constructing the core of thin sections, the currents cannot circulate through the iron. In the case of a solid core, the iron would have to be annealed to render it as "soft" as possible, to obtain the best magnetic effect. To the ends of the armature the steel shaft or spindle is fixed by brass end plates. One end of the shaft is hollow, and it is noteworthy that all modern machines are fitted with ball bearings to eliminate friction and wear. The armature core is insulated with varnished tape, and then the "primary" winding of thick,



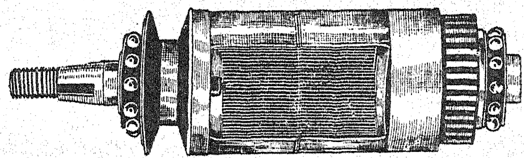
MAGNETO CIRCUIT

This diagram depicts the primary and secondary windings. The former completes its circuit through the contact breaker, and the secondary circuit is completed through the sparking plug, the magneto itself forming the return circuit for both primary and secondary currents.

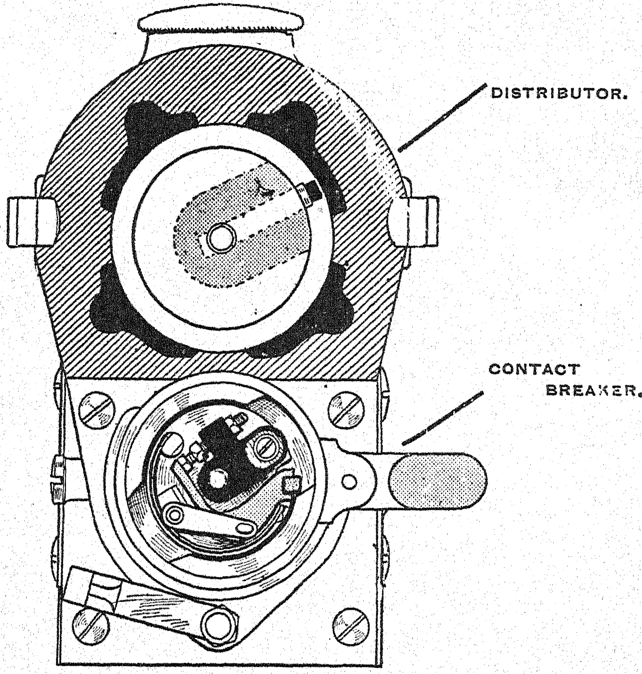
insulated wire carefully wound on. The beginning of the winding is connected direct to the core, or, as it is usually termed (incorrectly), "earthed." The finishing end is passed down through an insulating tube into the hollow shaft. This winding is very carefully insulated, and then over it is wound the "secondary" winding, composed of many turns of fine wire (42 or 44 s.w.g.), insulated with silk and soaked in paraffin wax. The beginning of this winding joins to the end of the primary. The finishing end is also taken through the centre of the shaft inside an ebonite tube. The primary now makes a connection with the interrupter device, or make-and-break. The secondary or high-tension end of the windings makes a connection with the distributor by means of an insulated "slip" ring and brush.

Carbon Brush: Distributor, Condenser

There are several methods of making the connections; usually a carbon brush pressing on an insulated ring is adopted, thus allowing the armature to rotate freely, and also enable the induced current to be drawn off. The distributor is, in effect, a rotary switch, specially insulated and provided with a number of contacts equivalent to the number of cylinders on the engine. An important part in a high-tension magneto is the condenser built up of a large number of paraffined paper or thin mica sheets, interleaved with tinfoil. It is made up into a compact block, and connected in such a way that it forms in effect two large sheets of foil separated by the insulation.

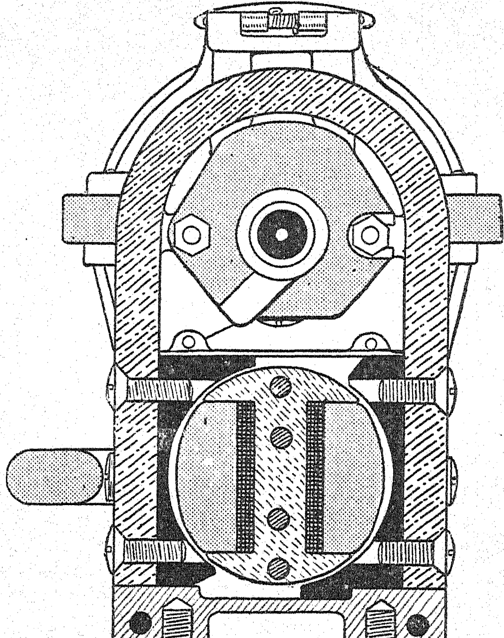


Complete armature of a magneto. The condenser is mounted in a case on the right-hand end as shown. The small pinion engages with the large gear wheel of the distributor. This gear wheel is twice the diameter of the armature pinion. The collector ring, or "slip ring," is on left. The ball bearings and the taper seating or the driving sprocket or pinion are also shown. The contact breaker, which is a detachable unit, fits on the extreme right-hand end of the armature.



End view of magneto (with covers removed) showing the contact make-and-break mechanism with its adjusting arm for advancing and retarding the timing. Above the contact make-and-break is seen the high-tension distributor with its four metal sectors on which lightly presses in succession the carbon brush conveying high-tension current from the armature. The carbon brush of the distributor rotates at half the speed of the armature.

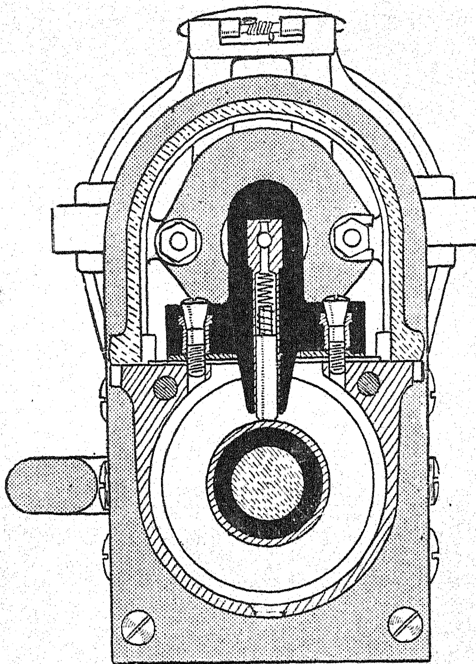
The position of the condenser is shown in the illustration of the armature. Current is induced in the primary winding at the moment when the lines of force are suddenly diverted from their path through the winding to the path through the iron cheeks of the armature. The winding is at this moment a closed circuit, but just on the point of being opened by the cam striking the "make-and-break." This sudden interruption of the circuit at the instant of maximum induction induces



Vertical section through magneto, showing arrangement of magnets and pole pieces. The armature core with its primary and secondary windings is also clearly shown in the dark and light shading within the core spaces.

a high-voltage current in the secondary winding. It is at the moment of interruption of the circuit that the condenser comes into action by allowing the charge in the primary winding to expend itself quickly. In a sense it is a similar action to a spring taking up a sudden mechanical shock. If the condenser is properly made and proportioned, there will be little or no sparking between the platinum contacts, and the circuit will be completely and instantaneously interrupted. Without a condenser heavy sparking would occur, and the "break" would be delayed, and the high-tension current seriously weakened. A current is induced twice per revolution, and the distributor is geared proportionately with the armature to give the correct number of sparks according to the number of cylinders the engine is provided with. The correct timing of the ignition moment relative to the piston

position is of great importance. As before explained, there is a particular position during the rotation of the armature between the poles of the magnets when the induction of current will be at a maximum value; the moment of interruption of the primary circuit should therefore synchronize with it. If the timing is required to be made later, and the contact make-and-break moved bodily through so many degrees of angular movement, it must follow that the armature will



Vertical section through magneto, showing the high-tension collector ring on armature. On this presses a carbon brush which conveys current from the high-tension winding of the armature to the distributor, the back part of which is visible. The solid black circle represents the insulation of the collector ring surrounding it. This latter is of brass.

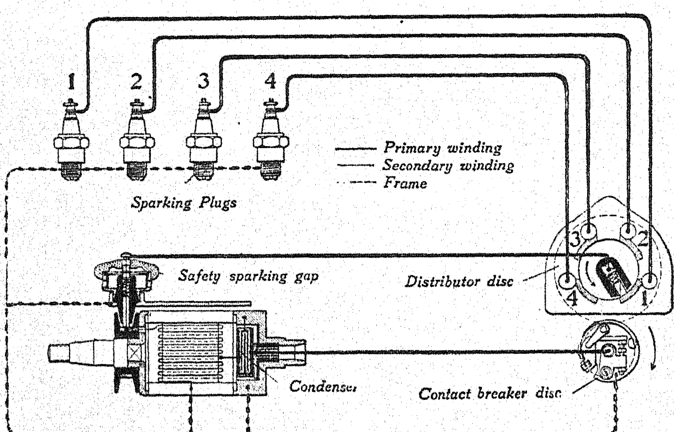
have moved past its best position for induction into a less favourable one. By using a very powerful set of magnets, however, it is possible to compensate for this disadvantage. Another method is based on the fact that the strength of the induced current is proportional to the speed of rotation. If, now, the "maximum" induction and maximum retardation positions agree, the current will be at a comparatively high value, even when the speed is low, so that it is possible to obtain a spark strong enough to start on. When advancing the ignition, although the armature is in a less favourable position, the speed will be higher than before and compensation thus obtained.

Combined Magneto and Coil

This form of machine, used to some extent on American cars, generates a low-tension current in the armature, and is fitted with make-and-break mechanism as in other types, and in general design, is similar. This low-tension current is discharged into an induction coil, differing very little in principle from an ordinary coil as used with accumulators. To make the machine self-contained, it is usual to fix the coil under the arched portion of the magneto, this space not being otherwise utilized. It is possible to get more wire on a coil than on the armature, and, as the high-tension circuit is kept apart from the armature, risk of breakdown is avoided, although the insulation of most double-wound armatures is so substantial that a failure is very rare.

The Safety Sparking Gap

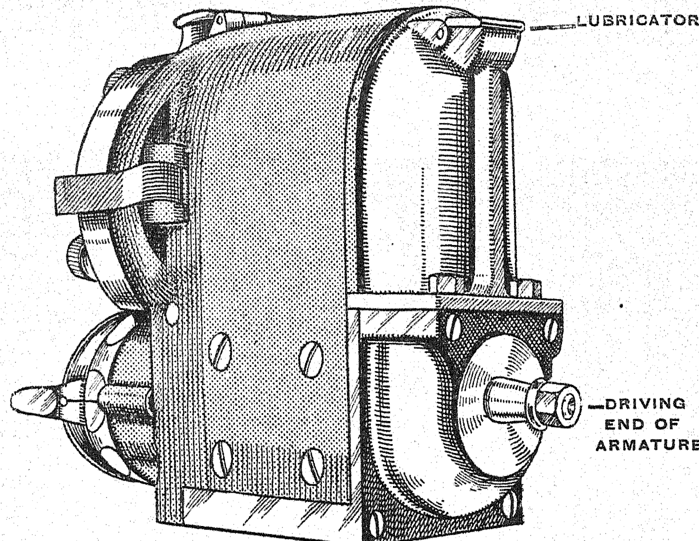
A device known as the "safety sparking gap" is used to prevent the magneto being subjected to undue strain, either by the machine being driven at an excessive speed, or owing to the normal discharge gap across the plug points being too wide. The safety gap forms a discharge point set to a predetermined distance from the frame, this point being in direct connection with the high-tension terminal. The current can therefore safely discharge if the normal path is cut off. This device is seen in the appended illustration. The passing of a spark or intermittent "flashing" at the safety gap, may be regarded as a sure indication that the ignition at one or more of the plugs is faulty, and the engine is misfiring. In this case the proper course is to replace the plugs successively till the faulty one is located.



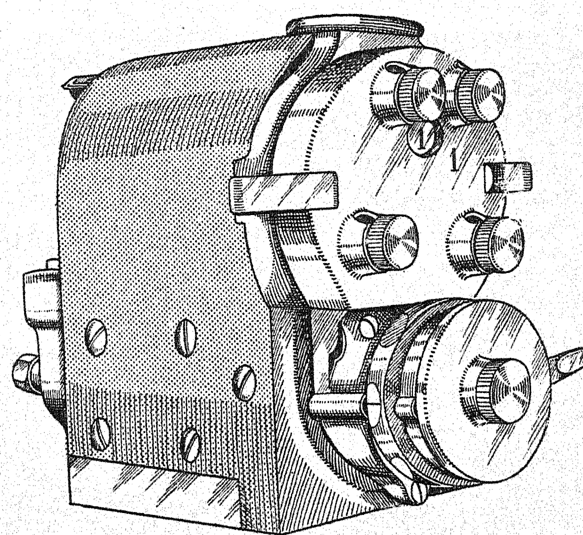
Scheme of wiring and armature circuits of four-cylinder magneto.

Magnetos for V-Type Engine

To produce a machine capable of firing cylinders set at an angle to each other proved a problem of considerable difficulty for some time, but very satisfactory magnetos adapted to meet this special requirement are now made. The difficulty which had to be surmounted was

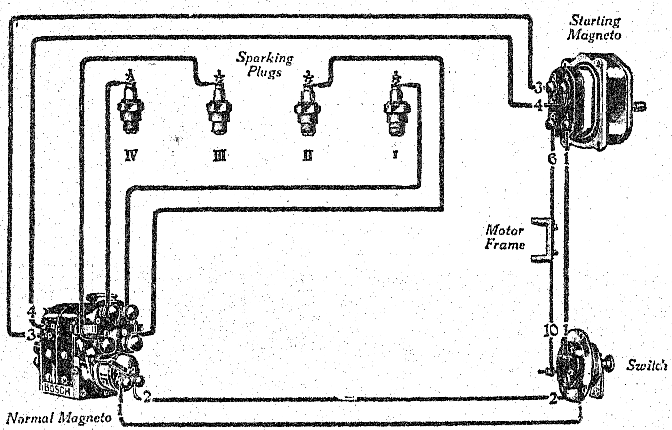


Exterior view of Bosch water and dust-proof magneto from driving end.



View from distributor and contact-breaker end showing the four terminals and timing indicator on the distributor cover. The lower terminal is for a switch connection to enable the current to be switched off when desired.

to obtain the sparks at irregular periods. The ordinary magneto has a symmetrical arrangement of "magnetic field," the maximum position occurring at each half rotation of the armature when a spark is produced at the plugs. In a V-type engine of two cylinders the connecting rods drive on to the same crank-pin, and according to the amount of angular deviation will be the proportion of irregularity in the firing interval. In one well-known V magneto the principle adopted is to have a peculiar form of pole piece to the magnets and a special armature. In the case of an ordinary machine the horns or edges of the pole pieces are quite symmetrical, but on the V magneto the horn of one pole projects towards the central line, and the one opposite is cut away. This is done in one direction for one half the length of the pole pieces, whilst for the other half the position is reversed so that there are two projecting poles at opposite corners and two blunt poles at the other corners. The armature has a somewhat similar disposition of the metal mass of the "core" adopted. This is best explained by regarding the ordinary armature as of H section, the two verticals of the H standing for the cheeks and the wire being wound on



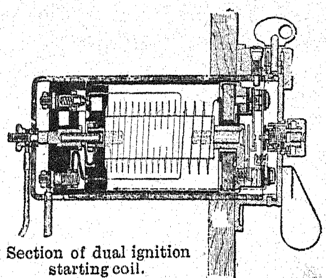
Plan of arrangement of circuits of auxiliary magneto, which is fitted on the dashboard of the car, to facilitate starting.

the horizontal connecting the two. In the V-engine magneto one cheek of the H is cut away for half the length on each side, so that there is really a T section at each end. The winding, however, is similar to that used on an ordinary machine. As previously stated, the maximum or spark-producing position occurs when the cheeks of the armature bridge the gap symmetrically between the poles In this magneto, as one pole is given a "lead," the maximum position is well past a central vertical line cutting the machine. Two currents are induced per revolution from each end of the armature, and supply the respective plugs

For V-type engines, with the cylinders set at 90 degrees, it is possible to use a magneto with a fixed armature and rotating iron shield between the pole pieces and armature. This type of magneto generates a current at each 90 degrees of rotation, and has to be driven at crankshaft speed. This magneto was one of the earliest types introduced, but is still made to meet special conditions.

Dual Ignition Coil and Engine Starter

The system illustrated enables an engine to be started from the dash by pressing a button on the starting coil. Only one set of sparking plugs is required, and a switch on the coil enables the magneto to be brought into circuit after the engine has been started on the coil and battery. The high-tension distributor and the contact-breaker on the magneto are used in either system, and in the improbable event of failure of the magneto, the engine can be run continuously on the coil. The latter is provided with a trembler, which can be brought into action to give continuous sparks by turning the starting button round; starting is thus facilitated if the sparks from the coil are not effective.



Section of dual ignition starting coil.

Auxiliary Magneto for Starting

An alternative system to dual ignition consists in the provision of a small high-tension magneto, but made without a distributor. The armature of the machine is geared up about four to one, and is rotated by a handle. A connection is made from the armature to the distributor of the main magneto, which has a special carbon brush holder provided. This is the only alteration required. This arrangement ensures that one of the cylinders, with the piston in a favourable position for starting, will be in contact with the auxiliary magneto, and, therefore, a partial turn of the handle of the latter will ensure a start. A duplicate drive to the auxiliary magneto can be made by fitting a flexible shaft and simple piece of gearing to the engine-starting handle, thus facilitating a start, should it be necessary to turn the engine round to induce a charge of explosive mixture into the cylinders.

The Magneto Switch

Although this is not indispensable a magneto is always provided with a special terminal, which can be connected up by a wire to a switch. It is not a necessity for control, as an engine is not controlled by cutting off the ignition, but in some instances it is useful to be able to switch off, as when using the engine compression as a brake or to stop the engine whilst leaving the throttle full open, so that some of the cylinders will retain a charge of explosive mixture and enable an easy start to be made. A magneto switch temporarily short circuits the armature windings, so that the make-and-break mechanism has no effect and no spark is generated.

Safety Lock to Switch

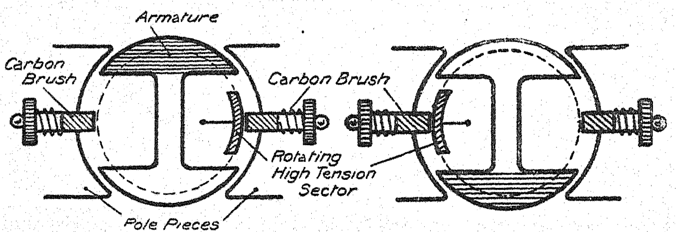
Probably the most useful advantage of a switch is that by locking it in the "off" position it prevents unauthorized use of the car, as the engine cannot be started. Magneto switches are now often provided with a lock.

Principle of Automatic Advance Magneto

As distinct from the ordinary magneto with a fixed timing point, or that with the usual variable timing arrangement controlled by the driver, there are a number of special machines by leading makers in which the timing is effected automatically, and a maximum intensity of spark assured for any given engine speed. This result is obtained on some machines by combining a centrifugal device or governor with the armature, which ensures that at all speeds the contact breaker of the magneto will operate at the point of maximum efficiency, as well as at the correct time with regard to piston position.

The Two-cylinder Magneto

The magneto for firing a two-cylinder engine is not so easy to understand with regard to the timing of the sparks as the single and four-cylinder types. Two-cylinder engines are made with different crank systems, one being set at 180 degrees and one at 360 degrees. In the former two explosions follow in succession, and then there is a long



Armature positions when generating current in two-cylinder magneto.

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Protection of Magneto from Wet and Dust

The latest types of magnetos are made thoroughly waterproof and also dustproof. The want of efficient protection was responsible for temporary breakdowns with the earlier types, owing to leakage of the high-tension current. On the latest magnetos all joints are hermetically closed by special watertight packing, and the terminals are similarly protected, and, therefore, no amount of wet or dust can interfere with the efficient working of the machine.

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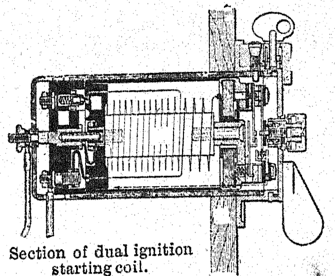

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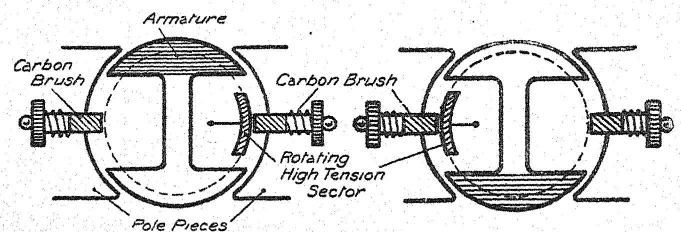

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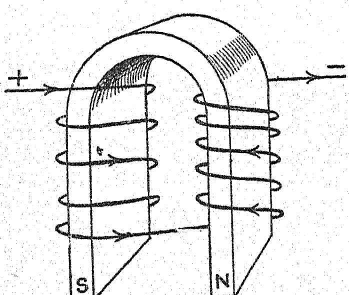
Ratio of Armature Speed to Engine Speed

A magneto must be positively driven from some part of the engine, because the armature movement and make and break must synchronize with the firing position of the piston. Taking a typical example of magneto, the ratios of armature speed would be as follow:—

Engine, Number of Cylinders.	Revs. of Magneto	to	Engine Crankshaft.
1	1		2
2 (If cranks are set at 180 degrees.)	1		1
2 (If cranks are set at 360 degrees.)	1		2
3	3		4
4	1		1
6	3		2
8	2		1

Restoring Strength of a Magneto by Remagnetizing

Magneto magnets are made of special tungsten steel, made so hard that a sharp file cannot make any impression on the metal. Much depends on the class of steel used—a special grade known as magnet steel being now always adopted—whether the machine will retain its sparking efficiency unimpaired for some years. The retention of magnetism by steel is a very curious and interesting property.

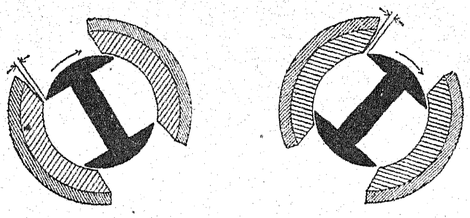


Illustrating principle of magnetizing a U-shaped piece of steel or iron by circulating a strong current round it. The direction of current and polarity produced are also shown. With a U-shaped hardened piece of steel the magnetism produced is permanent, with soft iron the magnetism only remains so long as the current is flowing. This makes a temporary or electro-magnet.

It resides only on the surface of the steel, and it is found that a much stronger magnet is obtained, weight for weight, by making it in sections, one placed over the other, than in using a massive single magnet. Most magnetos have three magnets superimposed, some have four. Soft steel is easier to magnetize than hard steel, but the former loses it quickly if submitted to vibration. The hard steel magnet loses its magnetism very slowly, although the magneto has, as a matter of course, to withstand much vibration from the engine, etc. Any standard type of magneto should show very little loss of strength for five years, but after this period it is as well, though not an actual necessity, to have the magnets brought up to maximum strength again. In all cases the makers or agents can do this with very little delay and at small cost. The magnetizing process requires the use of a powerful electro-magnet, across the poles of which the steel magnet to be strengthened is placed, so that opposite poles are always in contact.

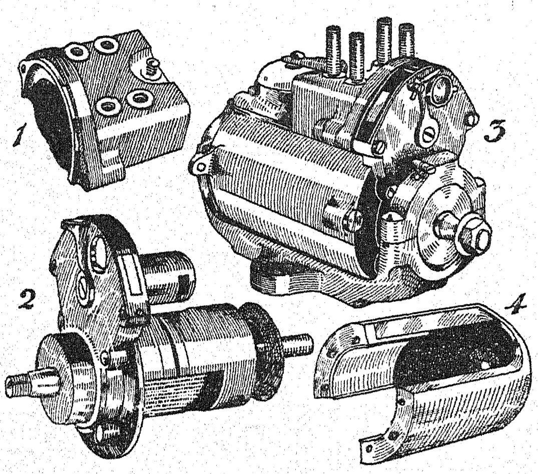
Magneto With Uniform Intensity of Spark

The ordinary magneto, as the previous descriptions will have made clear, has rigidly fixed magnets and pole pieces, and consequently the field of force is always in the same position relative to the armature. This means that when the spark is advanced or retarded by the angular movement of the contact breaker the actual break of the



Relative positions of pole pieces and armature in fully advanced and retarded position, showing that the "maximum position" is not altered.

armature circuit takes place at a varying position of the magnetic field, and consequently the intensity of the spark varies. At the fully-retarded position it tends to be weak, and when fully advanced it attains its greatest strength. Obviously the spark intensity should always be the same, especially as for starting it is necessary to retard



Mea magneto: 1. Cover. 2. Armature and distributor unit. 3. Complete machine. 4. Movable bell-shaped field magnet.

the spark to avoid risk of a backfire or sudden reversal of the starting handle and injury to the operator. In the "Mea" magneto the design is such that the magnetic field can be moved round simultaneously with the contact breaker so that the armature is always in the same

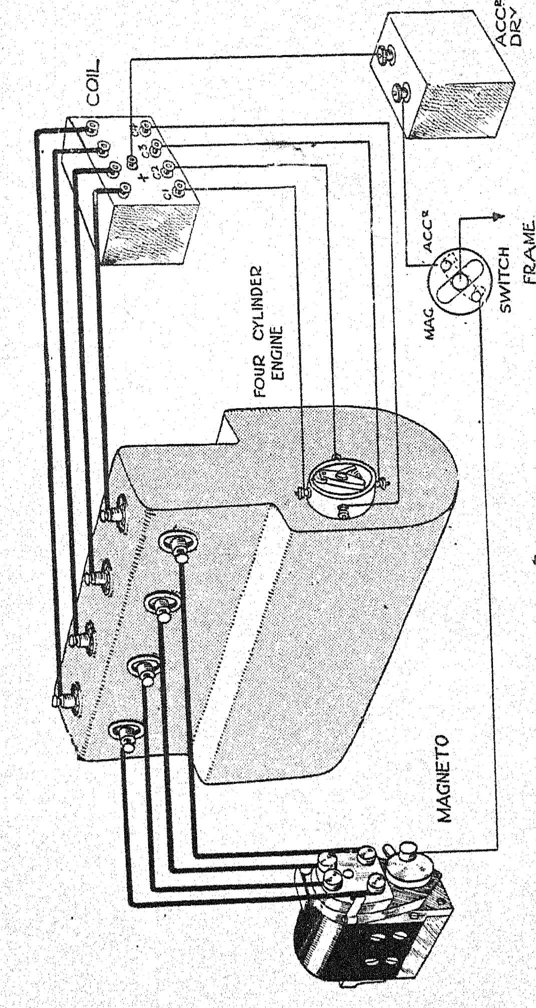


Diagram showing connections for dual ignition with two independent sets of plugs and wiring circuits, coil, contact make-and-break. The change-over switch connects up the magneto or coil independently, or both ignitions may be in action simultaneously by moving the handle still further to the right than shown. If the respective sparks are perfectly synchronized, slightly more power may be thus obtained than with a single ignition.

position relative to the field when the break occurs. This is effected by having a bell-shaped magnet mounted horizontally, the axis of the armature and the magnet coinciding. As the contact breaker is moved so also is the magnet to a similar amount, and the result is that the spark is of ample strength at the retarded position even allowing for the slow speed of rotation. This bell-shaped magnet, it is claimed, has some other advantages over the ordinary U-shaped magnet, inasmuch that it can hold a greater amount of magnetism and retain it at full strength for a longer period. The range of advance and retardation on this magneto is 40 degrees. The armature and distributor are made practically on the lines of the standard magneto with fixed magnets.

Care of a Magneto

It is almost an axiom nowadays that a magneto works best when it is left alone. At most it may require attention every 3000 miles of running. The magnets of the machine will—unless roughly handled —keep their strength for three to six years. Stated briefly, the attention a magneto requires is confined to the following:—(1) The make-and-break, the platinum surfaces of which must be kept well trimmed, carefully adjusted, and cleaned free from any oil, grease or dust. (2) The carbon brushes, two or more of which are used to collect the current from the armature and transfer it to the distributor. These brushes are liable to become clogged up with grease, or the springs may not act satisfactorily. (3) The ball bearings of the armature and distributor mechanism require periodically lubricating, and attention should be paid to the details given on this matter by the makers. (4) The connecting wires from the distributor to the plugs and also those joined to the switch, where such is fitted, must be examined occasionally to see that they are securely attached to the respective terminals, and that none of the insulation or rubber covering has become damaged or scraped off. Sometimes a loose wire will chafe against some adjacent metal work, and, with the insulation cut through, a short circuit (which may be either of an intermittent or permanent character) ensues. (5) The condition of the sparking plugs is very important. Faults may develop between the insulation and the metal shell.

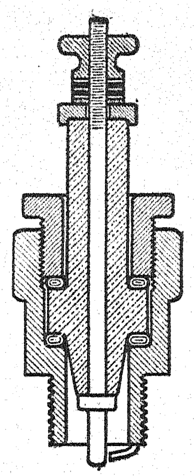
A Short Circuit at the Sparking Plug

A short-circuited sparking plug is a possibility. It is solely the result of a small thread of metal, from the electrodes, lodging across the gap and preventing the spark from jumping. The heat of the magneto spark is so great that the fusion of the metal of the plug points is sometimes caused. If, however, they are of substantial proportions, this rarely occurs. If a short circuit takes place between the electrodes, it can easily be removed by a thin knife blade.

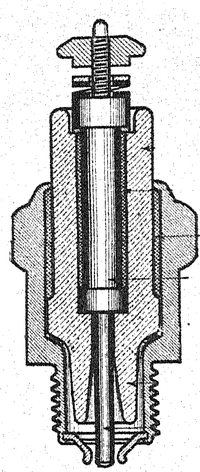
Setting the Plug Points

The best magneto plugs have heavy multiple sparking points of nickel. The adjustment or setting of the points is an important matter. The gap should not exceed 1-50th of an inch, or half a millimetre. The reason for this is the comparatively low voltage of the spark at the necessarily slow speed of rotation of the armature when starting up. It also ensures that there will be no risk of the spark failing to jump the points under the resistance offered by the highly-compressed charge.

A large gap between the plug points would tend to strain the insulation of the armature, that is the resistance at the sparking-plug gap under high compression would be so great that a spark might pierce the armature insulation and so pass to "frame." But taking a magneto as made nowadays, the care taken with the insulating of the winding is such that only very unfair treatment will cause a breakdown.



Showing general construction of an ordinary porcelain insulation sparking plug. A modification sometimes introduced is to recess the end of the porcelain and give greater insulation surface.



Sparking plug having a steatite insulator, welded by means of enamel to metal body. The central electrode is very massive, and the insulating sleeve is of considerable length.

Details of Sparking Plugs

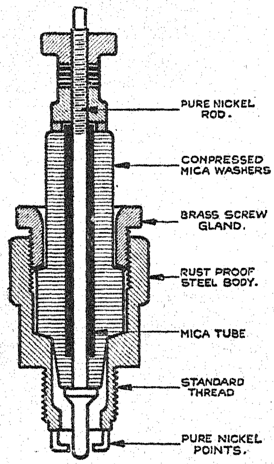
The sparking plug, as already explained, is a device for causing the ignition of the charge by an electric spark in the cylinder. It is made up of several parts of metal and porcelain or other insulator. The general construction is a metal shell or barrel which screws into the combustion chamber of the motor. Into the shell is fitted, perfectly gas-tight, by the use of copper asbestos washers, a porcelain, mica or steatite insulating core, through the centre of which passes a wire or rod terminating at one end in a sparking point or "electrode," and the other end is provided with a connecting screw or terminal for the high-tension wire from the magneto to be attached. The central electrode may be surrounded by several electrodes in connection with the outer metal shell or body. The electrodes are made either of pure nickel or nickel-steel containing 25 per cent. nickel. Platinum is sometimes used.

Although all sparking plugs are constructed on very much the same principle, there are various minor modifications introduced in different makes. Thus many types have some device for protecting the points

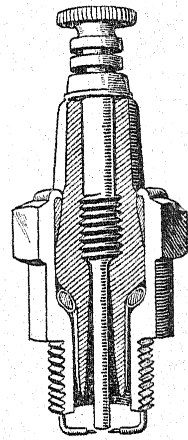
of the plug from lubricating oil thrown up by the piston, which would tend to produce a "short circuit" from carbon or soot deposit. Others are made with easily detachable parts, so that, in the event of one of them (such as the insulating core) becoming damaged, it is easily replaced at less cost than that of a complete plug. The standard thread for sparking plugs is 18 mm. diameter, 1.5 mm. pitch, angle of thread 60 degrees. Plugs are now made of varying "reaches," as it is found that some engines give better results if the sparking points reach further into the cylinder than the normal length of plug allows of. The theory is that the spark comes into more immediate contact with the mixture.

Cause of Plugs Sooting-up

Sparking plugs give very little trouble nowadays. Any standard type with ample insulation and stout electrodes may last for years, and only require occasional cleaning and adjustment of the electrodes. The only likely faults to occur are excessive sooting-up, due to running on an over-rich charge or inferior fuel. Having too much oil in the engine



Details of construction of a sparking plug with mica insulation, which is unbreakable. By this system of construction the components can be taken apart for cleaning or renewal.



Bosch one-piece plug.

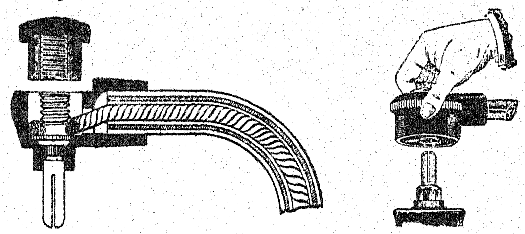
also may foul the plug. A crack in the porcelain may occur and put a plug out of action, but it is a rare occurrence. A few spare plugs should, however, always be carried on the car, as it is then easy to replace a defective one.

Increasing Power by Duplex Sparking

The ignition of the charge at two or more places in the combustion chamber of the engine will, within certain limits, ensure a more rapid combustion of the mixture, and this should tend to increase the power developed. Duplex sparking is generally used in high-speed work, such as track racing. The important factors in obtaining greater speed and power are that the sparks must occur mathematically at the same instant and must take place within the pure mixture; thus, it would not do to have one spark occur near the exhaust valve, as the mixture in

the vicinity of it is diluted with burnt gas. The plugs must also be connected up properly.

In the parallel connection the current from the coil or magneto terminal is divided into two circuits. It has been proved that there is no advantage in this method of connection; in fact, two plugs so connected will often give worse results than a single plug, and this is obviously because the two plugs do not synchronize in the firing moment and also because the current when divided between two plugs will not necessarily give as good a spark as when concentrated across one pair of electrodes. The series connection, which is the correct one, is entirely different, and, providing that the current has sufficient

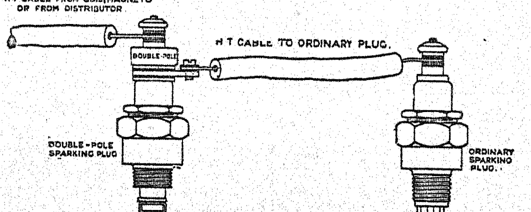


Sparking plug connectors enabling the high-tension cable to be attached or detached without any risk of the operator receiving a shock. The cable end is secured in the manner shown in the section. The connector is made of special insulating material.

voltage to jump across two gaps, the sparks are bound to synchronize. This cannot be effected with an ordinary coil and plugs, as two high-tension terminals are necessary to form the complete independent path for the secondary. But by using a duplex or double-pole plug connected in series with an ordinary single-pole plug two perfectly synchronized sparks can be obtained from an ordinary coil. It is important to make the spark gaps quite small (1-50th inch is correct), as the additional spark gap adds increased resistance.

Special Two-spark Magneto Necessary

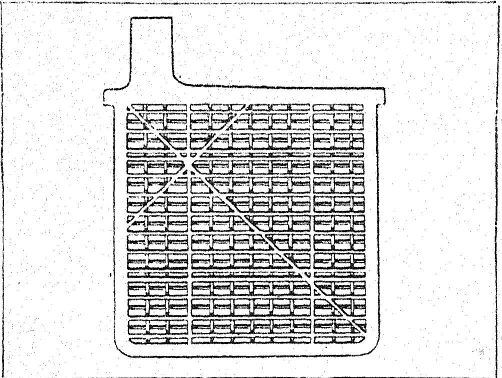
The practice of using two sparking plugs connected in series, although practicable with a coil, is not one that can be recommended with the standard type of magneto, the reason being that the resistance to the high-tension current offered by the extra plug puts more strain on the insulation of the magneto than it is intended for. There is, however, a special magneto obtainable for this purpose, which can be used with safety. In this case two ordinary plugs can be used. The makers point out that the advantage of two-spark ignition is very slight, unless the plugs are a considerable distance apart, but, given favourable conditions, the improvement in power is very marked.



Single and double pole sparking plugs connected in series.

Coil and Battery Ignition System

The universal adoption of the magneto renders any lengthy description of the coil system now unnecessary. It is referred to, however, in view of the fact that it may still be found on second-hand cars, although it pays as a rule to have a magneto fitted. The coil-and-battery system may be divided up into several modifications. The original system is that of a single coil and contact breaker. A later development was the introduction of the trembler coil, one advantage of it being that easier starting of the engine was obtained. The single trembler coil was introduced as an improvement on this, as the difficulty of adjusting a series of tremblers was thereby overcome. The single coil working through a high-tension distributor was an improvement over the single-trembler, multiple coil, because it was a simple matter to



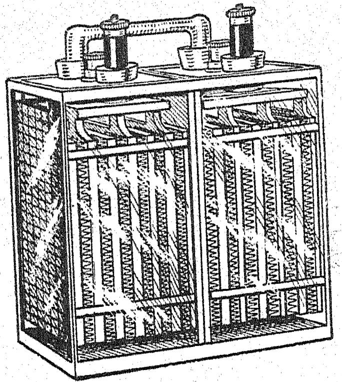
Ordinary grid used in accumulators. The spaces are filled with oxide of lead or "active material."

adjust it and it was much more compact than a range of separate coils. Special forms of coils have been introduced from time to time, amongst which is a coil giving a very intense and detonating spark and with all the features of the magneto spark.

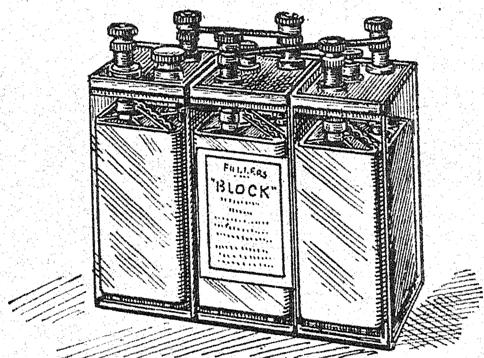
The Accumulator or Battery

consists of a set of lead grids or frames, filled solid with oxides of lead, these plates being immersed in dilute sulphuric acid contained in celluloid cases, so that the condition of the interior can be readily seen. The accumulator has to be "charged" from some source of continuous current—usually a dynamo. Certain chemical changes take place in the constitution of the plates which enable a current to be drawn from them at will. When all the chemical energy stored in the plates is converted back into electricity, the battery is said to be "discharged"; but it can be re-charged again by sending an electric current into it, when the chemical change is produced again. The operation can be repeated any number of times. The plates are different in colour, the positives (lead dioxide) being a deep chocolate colour, and the other set, the negatives, being grey (pure lead). The terminals on the case are for connecting up. The terminal connected to the positive plates is, as a rule, painted red to distinguish it, and to be able to connect up properly. A plus mark (+) denotes the positive connection.

The grids of an accumulator are constructed in a special manner, so that the lead oxide, or active material, is held securely in place. To further assist in keeping the plates in position, and resist the influences of vibration, expansion, and contraction, which tend to cause them to buckle and disintegrate, it is usual to provide celluloid or vulcanite stays or separators between each pair of plates.



Standard type of 4-volt ignition accumulator, consisting of two cells each of 2 volts connected in "series" (or positive to negative). In each cell there are three positives and four negatives. Each set of plates is connected across as shown; thus making one large plate of each set.



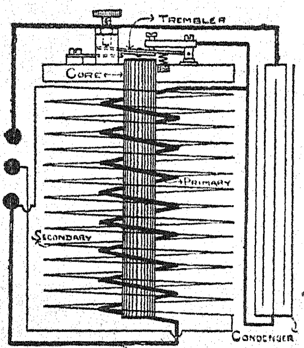
A three-cell solid or block accumulator giving 6 volts.

The Block-type of Accumulator

Although the standard type of grid or plate accumulator remains by far the most extensively used, a later type, known as the block cell, is coming into favour. In this type the positive element consists of a solid block of peroxide of lead, contained either in a porous casing or held in a sort of frame. The negative element is practically the same as in the plate battery. In some instances, however, it is made in circular form to enclose the positive element. This cell can be charged and discharged at a much higher rate than a plate cell without injury, thus saving time. Another advantage is that this form of cell can be left more or less uncharged for a much longer period without the ill-effects of sulphating taking place than a plate cell can.

The Ignition Coil

The fundamental purpose of a coil is to intensify or increase the pressure of the current from an accumulator or dry battery to many thousands of times the original voltage. The battery may give four or six volts only, but by passing it through the coil it is increased to something like 25,000 volts. The valuable characteristic of this high-voltage electricity for ignition is that it can jump across an air gap or break in the conductor a certain distance. For an ordinary ignition coil this distance would be from $\frac{3}{8}$ in. to $\frac{1}{2}$ in. in air at atmospheric pressure of 14.7 lb. to the square inch. In air or explosive mixture under a compression of 80 lb. to 100 lb. per square inch the distance that the spark can jump is greatly reduced, about $\frac{1}{16}$ in. being the maximum distance. The usual sparking-plug gap is not more than 1-32 in. for coil ignition. The construction of a coil is extremely simple. There are three chief parts, viz., a core or compact bundle of soft iron wires. Over this is wound neatly two layers of fairly thick insulated copper wire (the



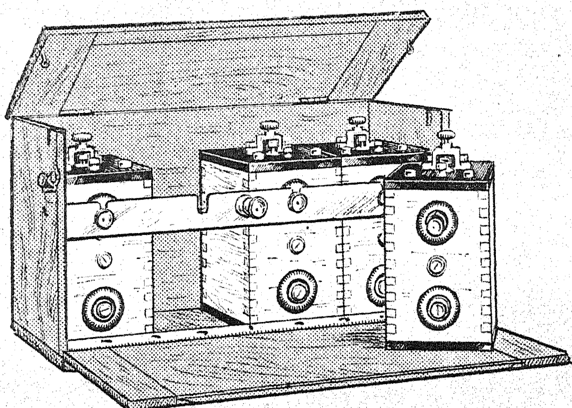
Arrangement of windings of a trembler coil. The three terminals on left connect up —Top to battery, centre to sparking plug, lower to contact breaker.

gauge is usually No. 16 or 18 standard wire gauge). Over this winding which is named the "primary," are wound from 15 to 20 layers of very fine insulated copper wire, usually No. 40 gauge. Every layer, both "primary" and secondary, is separated by a layer of waxed paper or some special and thin insulating material.

The secondary winding has no actual connection with the primary, its two ends being, in effect, joined to the sparking plug so that the complete circuit has to be made across the gap between the plug points. The primary winding is connected to the accumulator or battery, not directly, but through a contact breaker and a trembler or vibrator. The purpose of the contact breaker is to "time" correctly the flow of current through the coil to produce the spark exactly when the ignition of the charge in the engine is required. The vibrator is a small attachment on the coil itself, which is operated by the magnetism of the core, and its object is to produce a very rapid and intermittent interruption of the current as it flows through the coil. The result is that the electro-magnetic induction or influence, acting from the primary winding, generates a high-voltage current in the secondary winding just for so long as the contact breaker and trembler are in action. This, however, only lasts for a very brief fraction of a second. The complete theory of the coil is much more complex than the above description would convey, but sufficient has been stated to impart a working idea of the principle.

Contact Make and Break. High-tension Distributor

The coil system requires some means of sending current into the coil at the correct time; in the case of a four-cylinder engine this is twice per revolution of the crankshaft. This is effected by what is practically a rotating switch driven by the engine. Numerous types of contact make-and-break devices have been at one time or other introduced, but if one has to be used nowadays it is usually a type known as the roller pattern, which is as reliable as any and works with a minimum of friction. It consists, briefly, of an aluminium case of shallow and circular shape. Inside this is a ring of insulating material, in which are fitted, flush with the surface, four steel segments, and these are placed exactly equi-distant. To each segment is attached a terminal, which is



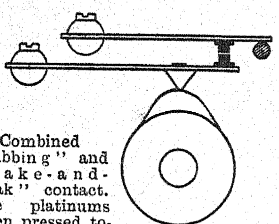
Trembler coil of the detachable Unit type, any coil can be taken out for separate adjustment of the trembler.

connected to the coil. Mounted on a central axis is a metal arm that carries a steel roller, which presses firmly on the metal segments. A spring adjustment ensures that the contact will always be maintained. The roller touches each steel segment in turn, and, as it forms part of the circuit, it will be obvious that it makes the desired contact at the correct times. The roller arm is usually attached either directly or indirectly to the camshaft of the engine, and thus, as it revolves at half the engine-shaft speed, it completes the four contacts in two revolutions of the engine. This device is kept lubricated, and there is very little wear and tear. The distributor does not differ greatly from the contact maker in principle, except that it is designed to distribute high-tension current to the sparking plugs from the coil at the correct time. The segments are usually insulated in a vulcanite ring or disc, and instead of a steel roller pressing firmly on them, the rotating metal arm carries a carbon brush, which presses very lightly on the segments. The construction is, in fact, practically the same as that of the distributor fitted to a standard magneto.

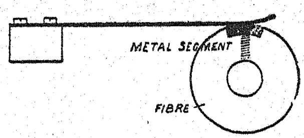
The Alklum Accumulator

This type of battery differs very considerably from the standard lead-sulphuric-acid battery just described, and has several distinctive advantages. It does not contain any lead or dilute sulphuric acid, and the

case or cell is of indestructible steel instead of the usual fragile celluloid, vulcanite or glass used. For a given capacity it is much lighter in weight than the lead cell, and its durability under the severe conditions of charge and discharge is very high. There is no deterioration of the plates or electrodes possible, and it can be charged at a very rapid rate without injury. As opposed to the dilute sulphuric acid of the lead cell, the liquid used in the Alklum battery is a dilute solution of caustic potash. This liquid is harmless to metal, and, therefore, the terminals and connections are not liable to corrosion. Instead of lead grids filled with peroxide of lead, the positive plate is made up of oxyhydrate of nickel with a certain proportion of graphite, and the negative plate is mainly composed of cadmium and iron alloy. The voltage per cell is 1.2 volt, as compared with 2 volts for the lead cell. The voltage remains quite steady practically right up to the point of complete discharge, and in this respect it has an advantage over the lead cell, which, under heavy discharge, falls from 2 volts to 1.8 volt.



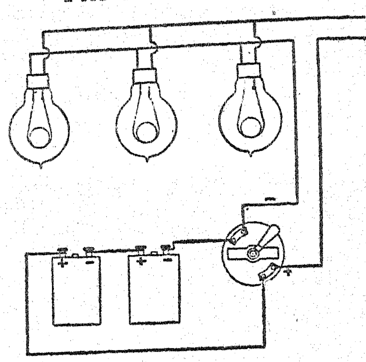
Combined "rubbing" and "make-and-break" contact. The platinums when pressed together slide across one another to a small extent and clean each other.



Simple "rubbing or wiper" contact for trembler coil.

The Charging of Accumulators

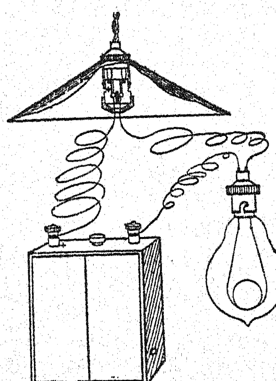
The recharging of accumulators is best done at a large garage or repair shop as, usually, these are properly equipped for the work. Home charging of accumulators is not done so much now as it used to be; as it is rather slow and expensive. The universal use of metal filament lamps in domestic lighting nowadays makes it a less convenient process than formerly; as the current obtainable through any individual circuit is comparatively small, and this means that more lamps have to be used in the charging circuit. It is important to remember that charging can only be done from continuous and not from alternating current, as the latter requires special appliances. Assuming, however, that it is desired to do the charging from a domestic supply, the simplest method is to "tap" the current at a switch. The cover should be taken off one of the switches controlling a group of three or four lights and the handle put *in the off position.* It is then necessary to find out which is the positive terminal on the switch. To do this, connect two lengths of insulated wire (bell wire will serve), one to each connection of the switch. Clean the other ends of the wire bright, and hold them apart in a glass of slightly acid or salt water. The wire connecting to the *negative* pole of the switch will give off bubbles of gas. Instead of this method "pole-finding" paper may be used. This is wetted, and the wires laid on but not making contact with each other. The negative pole is indicated by a red mark on the paper. It is only necessary to join this wire to the black terminal, and the other wire to the red terminal of the accumulator, and leave on for a sufficient number of hours to complete the charging. The lamps will remain alight, and with no very appreciable loss of brilliancy. It is important to note that the handle of the switch *must*



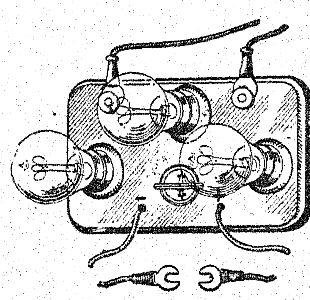
Charging two 4-volt accumulators in series from a lamp switch. The lamps which are used as a resistance to reduce the voltage must be of a definite candle-power to suit the "charging rate" of the cells.

remain off during the charging. When fully charged, the accumulator will give off gas freely, and the acid becomes a milky colour. The voltage will also rise to nearly 4.5. The number and candle-power of the lamps should be adjusted to suit the size of the accumulators.

Instead of tapping the current at the switch, it is often more convenient to connect the accumulator up to a lamp holder and charge through a single lamp of about 32 c.p. The requirements are a lamp holder, a fitting known as an adapter, and a couple of yards of twin flexible conductor. The adapter and lamp holder require to be wired as illustrated, the lines indicating one lead of the "twin flexible." The adapter is fitted into the main lamp holder, and the lamp is inserted in the new holder. It only remains to find which are the positive and negative ends of the wires, and then connect up to the accumulator as before described. The lamp used would be either an

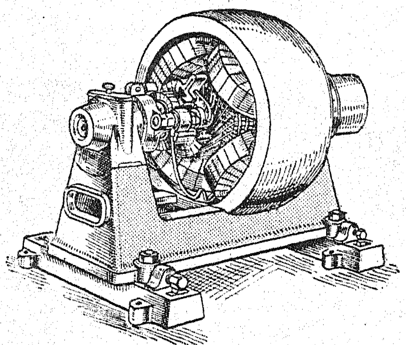


Charging an accumulator from a lamp holder through a lamp. Adapter in position. Carbon filament lamps are best adapted for charging through. This method avoids disturbing the switch or other connections.



Useful form of charging board for accumulators of various sizes. The lamps can be varied in number or candle-power to suit current output desired. The upper wires connect to the lighting circuit, and the lower ones to the accumulators. A magnetic needle form of current direction indicator is fitted.

8, 16, 32, or 50 c.p., according to the size of the accumulator and the voltage of the lighting circuit. During charging the vent plugs of the cell must be removed to release the gases generated during the process.



Standard 4 pole type of small charging dynamo as used in repair shops and garages. The output of current ranges from 5 amperes 12 volts to 12 amperes 30 volts.

Voltage Indicators

A fully-charged accumulator should show 2.25 volts per cell. The fall in voltage down to 1.8 volts per cell depends on the amount of charge left in the plates. The use of a sensitive voltmeter will show approximately the condition of the battery. Another method is by testing the specific gravity or density of the sulphuric acid, which density is at its highest when the cell is fully charged, and becomes less as the cell is discharged. This is the principle of the glass-bead indicator fixed to some cells. The beads are of various colours, and the particular number of these that float is a measure of the amount of charge left in the cells.

Storing Accumulators for Long Periods

(1) If an accumulator, of standard type, has never been charged, wrap it up or store it in a *dark* dry place. (2) If it is desired to put away an accumulator that has been charged for an indefinite period, discharge it through a lamp till each 2-volt cell registers 1.9 volts, then empty out the acid and let it dry off, and store as (1). The slight film of sulphate formed in drying (if any) will disappear at the first charge. (3) If a charged accumulator is to be put away for any period up to six months, charge fully, wipe the case perfectly dry, and grease the terminals. Store in a dark dry place free from dust. At the end of the time very little of the charge will have been lost.

When charging during the time the lamp is required for illumination, and to avoid loss of light, a special lamp of from 5 to 10 volts lower than normal voltage may be used. The older type of carbon filament lamp is the more convenient for charging through, owing to the much greater current consumed per lamp, as compared with the more modern metallic filament lamp. This means that a less number of carbon filament lamps are required to pass a given amount of current.

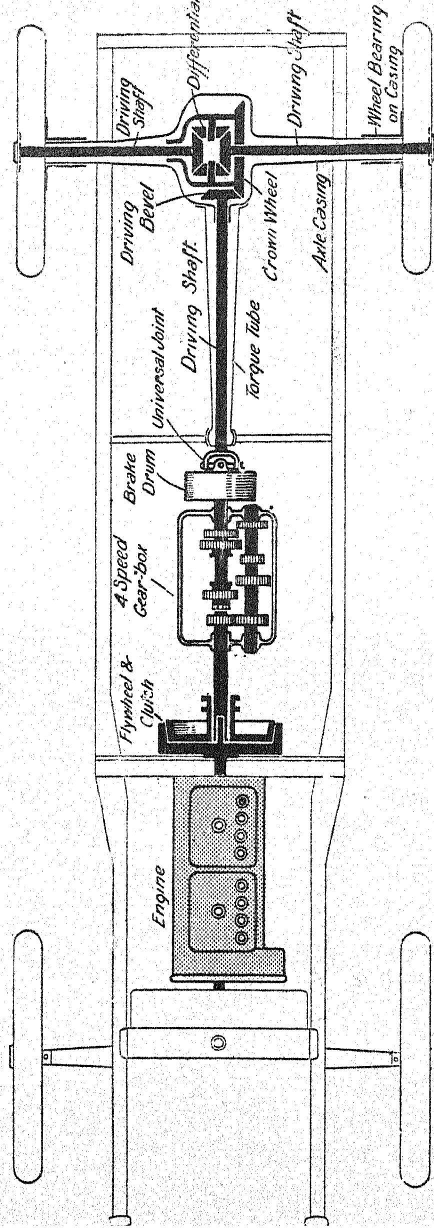
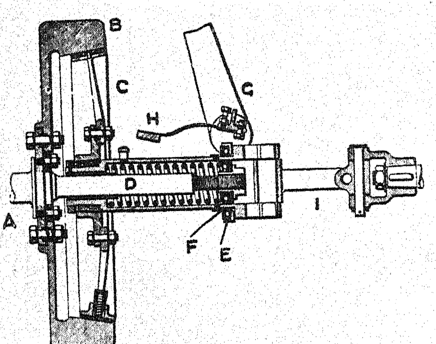


Diagram of general scheme of transmission of power mechanism from engine to road wheels.

CHAPTER V

Power Transmission Systems

Before the power developed by the engine reaches the driving wheels of the car it passes firstly through a clutch, and thence to a shaft which is connected to the change-speed gear system; from this another shaft connects up to a differential gear mounted upon the driving axle or rear axle. The clutch, by disconnecting the motor from the transmission system, enables the motor to be started up easily by hand, and allows the power to be transmitted gradually to the driving wheels to put the car in motion; and it also forms a means whereby the power can be immediately cut off from the driving wheels of the car when required, enabling the driver to have a very effective control over the running, and to stop suddenly if required. The simplest type of friction clutch consists of a turned cast-iron drum bolted to a flange on the crank shaft. This drum is tapered inwards and a coned boss fitted on a key or square on the end of the transmission shaft is arranged, so that it can be moved laterally on the shaft and thrust into the drum. This coned boss has its face or periphery covered with leather, and when pressed home by a spring the friction between the two surfaces gives practically a solid coupling; but when not pressed hard in, a certain amount of slip takes place, allowing the power to be put on gradually.



Simple form of leather-to-metal cone clutch.

A, Engine crankshaft.

B, Flywheel and clutch drum.

C, Leather-covered clutch cone or "internal member."

D, Extension of crankshaft with clutch spring mounted on it.

E, Thrust bearing.

F, Collar for actuating clutch.

G, Pedal arm.

H, Clutch brake pressing on sleeve. This prevents the cone "spinning" after disengagement, which would interfere with gear changing.

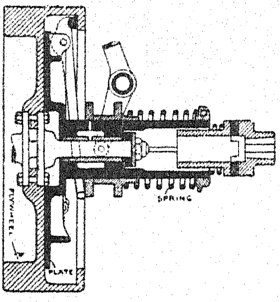
I, Coupling between clutch and gearbox.

The movement of the cone along the shaft is controlled by a simple system of levers, which the driver manipulates by foot pressure on a pedal conveniently placed. Another type of clutch now much used is the metal-to-metal or disc variety. Instead of using leather against cast-iron, the friction is obtained by forcing a number of steel plates or discs into contact, the pressure being obtained by a spring as in the former type. The plates or discs run in oil contained in a metal case. The film of oil on the surface of the plates acts as a cushion when the plates are forced into contact, the pressure gradually squeezing the oil from the surfaces before positive engagement. An alternative

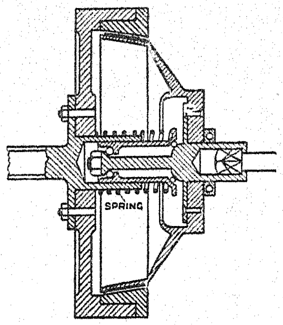
type of plate clutch has only one plate, but it is of considerable area. Sufficient pressure is obtained by a simple leverage system. Another type of plate clutch has a leather or asbestos fibre plate in between two metal plates.

Lubrication of Plate Clutches

Metal disc or plate clutches are now so well designed that there is rarely any trouble with them, providing the lubrication is carefully attended to. It is very important to use the class of lubricant recommended by the makers of the car. This is generally a special light-

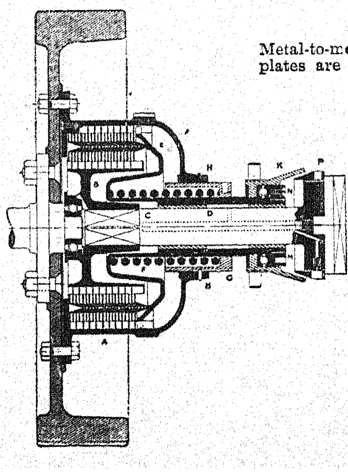


Metal-to-metal clutch of the single plate type. Pressure is obtained by a spring acting through compound lever against the plate.



Leather core clutch of internal type having no end thrust, sometimes termed an "inverted" cone clutch.

bodied lubricant or a solution of partly saponified oil. In cold weather the density of the lubricant has an important effect on the working of the clutch. If the oil has thickened the plates may not disengage properly, and thus render it difficult or impossible to change gear. If such difficulty is experienced, the clutch should be thoroughly cleaned out with paraffin, and the case filled to the required extent with fresh



Metal-to-metal clutch. A large number of thin plates are used, each pair forming a miniature cone clutch.

Details of clutch.

A, Outer dust-proof case which forms oil bath.
B, Steel inner core.
C, Clutch shaft.
D, Sliding sleeve.
E, Presser.
F, Central control spring.
G, Spring adjusting cap.
H, Adjuster lock spring.
K, Actuator.
M, Lock nut.
N, Locking device.
P, Coned clutch brake, which comes into action automatically and prevents clutch spinning round.

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Cone-clutch Improvements

A few seasons ago it was thought that the metal clutch in its various forms would practically supplant the simple leather-to-metal cone clutch. In its original form the latter had certain drawbacks, but its prime simplicity of construction and the very small amount of attention it required to keep it in order have regained for it in a large measure its former popularity, and, as a consequence, it now predominates in numbers as compared with the metal clutch. It has also been greatly improved, and its early faults practically eliminated. The cone, which is usually made to an angle of from 9 to 12 degrees, is constructed of pressed steel or an aluminium alloy to reduce the weight as much as possible. This greatly minimizes the tendency of the cone to continue revolving after disengagement, so that the gear can be changed with greater ease. Leather as a covering for the cone has to a large extent been supplanted by special asbestos-fabric covering, which is hydraulically pressed to shape without a join. Unlike leather, it is not adversely affected by the heat of friction generated when the clutch is slipped. Neither is it affected by oil or moisture. The modern method of mounting and centring the clutch are much improved, so that the old-time faults, such as noise resulting from inaccurate alignment, do not occur. The cone is not always arranged in the original way, i.e., with its narrow end inwards, but in some cases the position is reversed. The chief advantage is that there is no end thrust from the spring when the clutch is engaged.

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To enable a moderate amount of engine power to suffice to drive a car over every sort of road, including the hilliest parts, which, in exceptional cases, may have a gradient as steep as 1 in 4, even in this country, some means have to be employed to increase the leverage between the engine and road wheels in proportion to the steepness of the gradient. This function is performed by the change-speed gear. It does not in any way actually increase the power available, but enables the car by a sacrifice of speed to climb hills. The gearbox is, in effect, a convenient arrangement of levers, which greatly reduces the road-wheel revolutions as compared with the engine revolutions. There is, however, always a permanent gear ratio or reduction between the engine and road wheels arranged in the back axle. This fixed ratio ranges from a 3 to 1 to 4 to 1 reduction for medium-powered cars. The change-speed gearbox gives three or four more reductions at will; the lowest of the gears and the one that would give the greatest amount of leverage may give a 16 to 1 ratio, and the road wheels would revolve at 1-16th the engine speed. This very low ratio would actually only be used as an emergency gear. The other three ratios would be approximately: second speed $8\frac{1}{2}$ to 1, third speed $5\frac{1}{2}$ to 1, fourth speed (this being the permanent reduction in the back axle) $3\frac{3}{4}$ to 1. Gear ratios vary considerably with the type and power of the car, hence the ratios given are not to be taken as an actual standard. Apart from hill-climbing, the lower gears enable the car to be started from rest, the greater leverage exerted easily overcoming the car's inertia; otherwise, to start the car on a high gear would, in most cases, stop the engine. The gearbox also contains the "reverse," an extra gear, and usually of a very low ratio, which reverses

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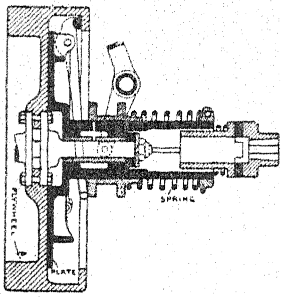

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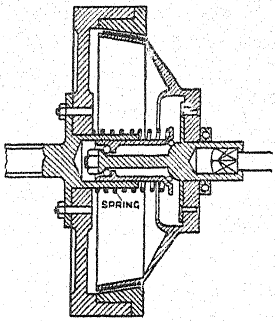

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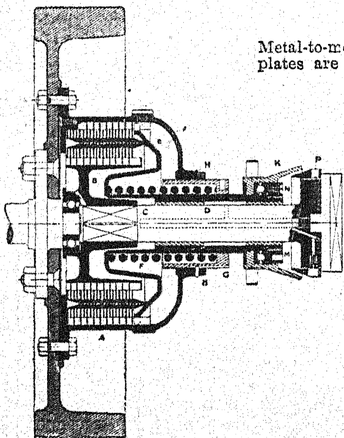

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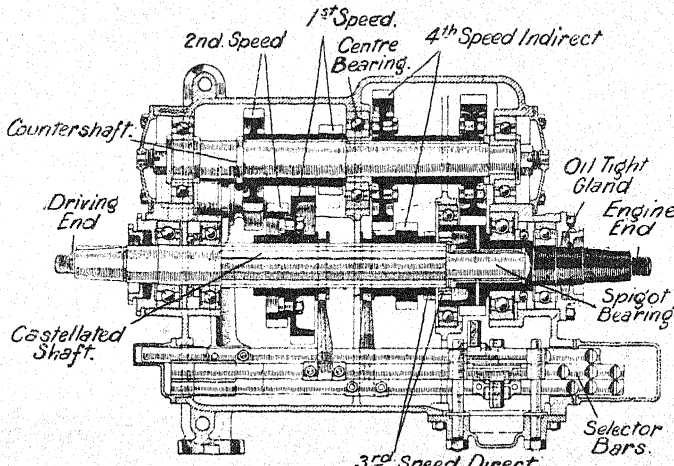
the direction of the car's movement, the engine itself being non-reversible. The same operating lever serves to actuate the several forward speeds and also the reverse, so that the control is both convenient and quick.

Gearbox Construction

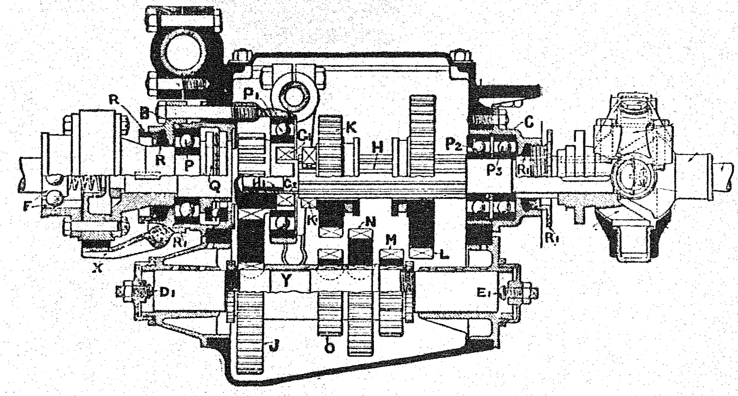
The fundamental principle of a change-speed gear is that of utilizing a system of toothed wheels that can be brought into engagement. These wheels are of different diameter and are fixed to two shafts, which are respectively the driving and driven shafts. To reduce the speed of the driven shaft and proportionately increase its leverage, it must have a large-diameter gearwheel engaging with or "meshing" a smaller one



FOUR-SPEED GEAR

An example of a four-speed gearbox, the third gear being a direct drive. The various speeds are obtained by meshing the pinions indicated by the converging lines, the third gear is obtained by an internal meshing pinion or a "dog" clutch. It will be noted that there are two gear sleeves operated by the selector bars and forks, the respective sleeve being moved to right or left according to the gear desired, thus for the first speed the left-hand sleeve is moved over to the right side, bringing it into engagement with the small pinion on the countershaft. Moved to the left it gives the second speed. The other sleeve gives the third speed on the right, and fourth on the left. The reverse pinion cannot be seen, but it comes into mesh between the second gear pinions. The illustration shows the application of ball bearings to a gearbox, the countershaft having a centre bearing to keep it rigid and free from springing. The lower shaft is sometimes termed the "primary" shaft, and the upper shaft the "secondary" or countershaft. The illustration is of a gearbox in plan and the shafts are, of course, side by side. It should be pointed out that the indirect geared up fourth speed is nowadays not adopted as a standard, the usual four-speed gearbox having direct drive on fourth speed.

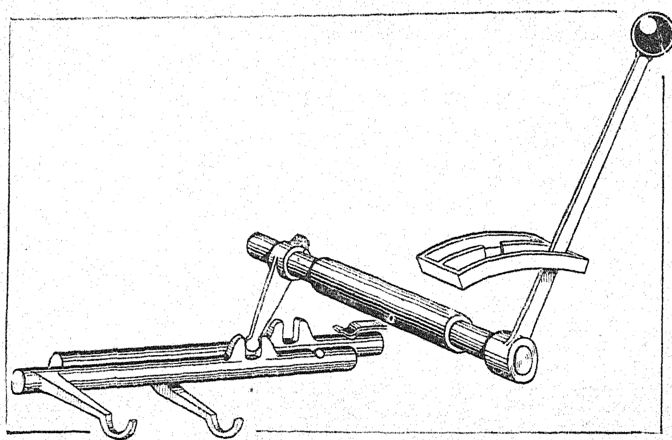
on the driving shaft. By having different diameters of gearwheels arranged in sets on the driving and driven shafts, ratios of any required value can be obtained by engaging them in succession. Although the gearbox is often contended to be a faulty mechanical device by reason of the principle of sliding or clashing the gears into mesh, it works remarkably well in practice. At times, and especially if unskilfully handled, it is subjected to severe shock, but it is able to withstand such usage largely because the steel the gears are made of is specially



Vertical section through three-speed gearbox, Rover type. In this it will be noted that the two shafts are placed vertically instead of horizontally.

A universal joint (F) conveys power to the primary pinion (G), bushed at G2, and providing a spigot for main shaft (H), which is also bushed at H1. The primary pinion runs in constant mesh with the wheel (J), keyed to countershaft (Y), running on large-size plain bearings (D) and (E), with adjustable pins (D1) and (E1) taking up end thrusts. The first speed is provided by allowing wheel (L) to engage wheel (M), which, in common with wheels (N), (O), and (J), is keyed to countershaft, running solid at all speeds. Second speed:—The wheel (L) is disengaged from M, and K meshed with N. For the third speed K is moved forward, allowing the jaws (K1) to engage similarly-shaped jaws (G1) on primary pinion, the whole shaft then running as direct drive. Wheel (O) meshes constantly with one wheel of a pair running solid with each other on suitable bearings on the reverse shaft (not shown), the reverse drive being obtained by moving wheel (L) into engagement with the other wheel on the reverse shaft.

tough and durable. Noise and vibration from the gearbox are nowadays practically eliminated owing to the teeth being cut to a mathematical degree of accuracy. Friction and loss of power are avoided by mounting the gearshafts on ball bearings and running the gears in a lubricant. With a very few exceptions, the earlier form of gearbox, known as the "straight-through" type, described in former editions of this book, has been abandoned in favour of the modern "selective" type of gearbox. The general construction is briefly on the following lines: There are two shafts in the gearbox; one of these is in line with the engine shaft and connects right through to the rear axle. On this shaft there is mounted two gear sleeves, each having two gearwheels on it.



"Gate" principle of change-speed gear lever. The long vertical hand lever can be moved both endways and sideways in the gate quadrant. The transverse shaft carries an arm which can engage one of a series of slotted lugs on the "selector" bars, which have forked extensions which engage the respective gearwheel sleeves. Only one sleeve at a time can be actuated; the non-operative selector bar is held in position by a spring catch, so that its gear sleeve is kept out of mesh. A latch or stop is usually fitted in the gate quadrant to prevent inadvertently going into reverse.

These sleeves can be moved by means of "forks" laterally on the shaft, but they must turn round with it, because the shaft is slotted, the gear sleeves having corresponding keys to fit in the slots. Alongside the through shaft is another shaft called the countershaft or layshaft, with a set of gearwheels rigidly keyed to it. One or other of the movable gears can be made to engage or mesh with one of the fixed gears, and thus take its drive from it. The layshaft, it is important to observe, is permanently geared to the engine, and the through shaft can, at will, be disconnected from the engine so as to take its drive indirectly from the countershaft. When none of the lower gears are in use, the through shaft is rigidly connected up to the engine by a clutch in the gearbox. The several movements of the gear sleeves that have to be made to bring the respective gears into operation will best be followed by reference to the illustration and description of a standard type of gearbox.

Gearbox Improvements

The standard three or four-speed gearbox has been brought to a high state of efficiency. This is largely the result of steady improvement in the design, but some of it is due to the high grade steels used for the gears, which are, given fair treatment, practically indestructible. The gate system of operation makes gear changing much simpler than with the earlier "straight-through" type of gearbox, and the gears are therefore subject to less misuse. A very high degree of accuracy in the cutting of the teeth and the use of shafts of ample diameter to avoid spring or "whip" renders the gearbox a comparatively noiseless piece of mechanism.

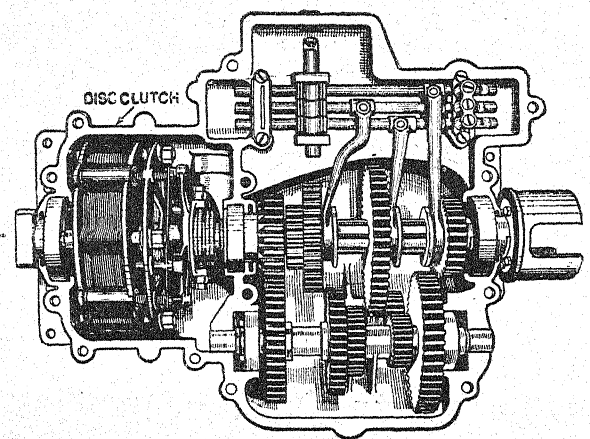


Illustration of four-speed gearbox, designed on the selective gear principle. The fourth speed is indirect, the through or direct drive being on the third speed, obtained by moving left-hand sleeve further to left; moving it to the right to mesh with countershaft pinion gives the second speed. Moving the next sleeve to left gives the first speed, and to right gives the reverse. The fourth indirect gear sleeve is on extreme right, and is moved to the left and engages large countershaft pinion. The disc clutch arrangement forms a complete unit with the gearbox.

Other Types of Gearboxes

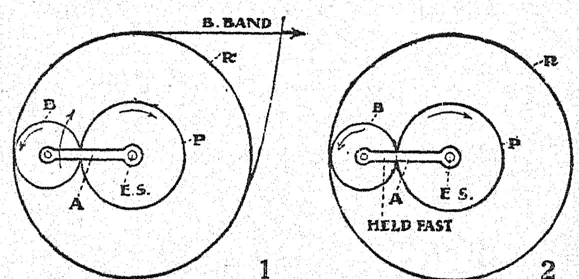
Whilst the sliding gear is the type vastly predominating in modern car practice, there are some modifications. The chief of these is the always-in-mesh gear. The principle adopted is to have the respective gearwheels permanently meshed, so that there is no risk of damaging the teeth by the usual act of sliding them into engagement. Obviously, if the gears remain in mesh some means must be employed to connect them at will to the shaft upon which they are mounted. This is effected by the use of clutches which revolve with the shaft and which, by a sliding movement, can be made to grip the gearwheels and thus cause the shafts to revolve at the speeds determined by the enmeshed gears. Somewhat similar in action is the chain-drive gearbox, but, instead of the gears being directly meshed, they are connected by silent-running chains. Although this type of gearbox is not used for private cars, its success for heavy vehicles makes it a potential future type.

Electric and Pneumatic Gearbox Operation

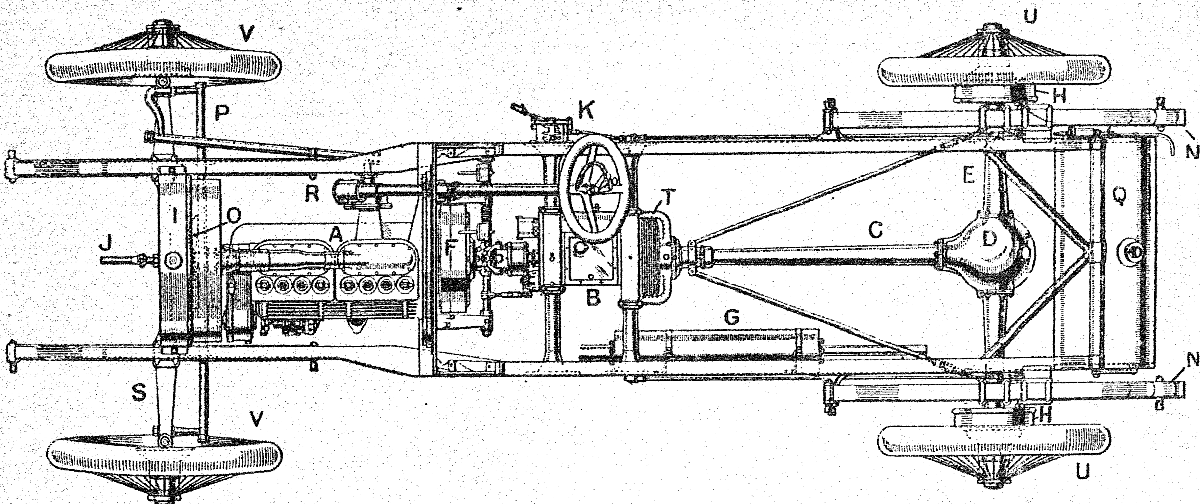
From time to time efforts have been made to adapt electric or pneumatic methods to do the actual work of changing the gear and thus relieve the driver of considerable manual work, as well as ensuring a better timing of the change and avoiding risk of damaging the gear. The use of electric and pneumatic installations for starting the engine has again brought forward the question of the application of the same forces to operate the change-speed gear, and, in fact, a small number of cars have some such system. Of the two, the electric principle is the more promising, owing to the ease with which the energy can be applied. The basis of operation is the use of a series of solenoid electro-magnets, which, by powerful attraction on an iron armature, causes the movement of the striking gear that puts the respective gear sleeves into operation. The driver controls the various changes of gear by a series of small switches on the steering wheel.

Principle of Epicyclic Gearing

The principle is entirely different to the sliding gear, and is the more mechanical system. Although at present the sliding gear is universally adopted, and several well-known epicyclic gears have disappeared as standard productions in deference to the demand for the sliding gear, it is always a possibility that the epicyclic gear may be revived. An important advantage of this system is that the gear-wheels are always in mesh, thus avoiding the risk of damage. Changing gear is effected by tightening a brake-band (or some similar device) on the gear, whence it is evident that the operation can be carried out without jar or shock and without noise. It will also be noticed, since there is no need to wait till certain parts have stopped revolving or slowed down to effect the change gently, that this can be done instantaneously, so that the car will not have lost its speed to anything like the extent it would with sliding gear. The epicyclic gear, if well designed, can be enclosed in quite as small—in fact, smaller—space as the sliding gear. The principle of these gears is "holding or releasing different parts of a gear always in mesh." This may sound somewhat difficult of comprehension, and, inasmuch as seeing is more to be



depended upon than hearing, so a diagram explains much more simply than a written statement what takes place. R is a ring with teeth cut on the inside (1), P is a toothed pinion keyed to the engine shaft, while A is an arm revolving on that shaft, but not keyed thereto. This arm (A) has a short axle at its extremity, which carries another pinion (B) gearing with the internally-cut ring (R), as well as with central pinion (P). Now, suppose P to turn round once with the engine shaft in the direction of arrow; R,



CHASSIS OF CAR WITH ENCLOSED SHAFT AND BEVEL DRIVE

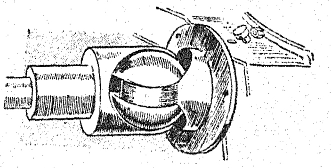
(A) Four-cylinder engine (cylinders in pairs). (B) Gearbox. (C) Propeller shaft enclosed in a torque tube. (D) Casing enclosing differential gear and bevel drive. (E) Live axle outer casing. (F) Clutch and fly-wheel. (G) Silencer. (H) Rear brakes. (I) Radiator. (J) Starting handle. (K) Gear changing quadrant and lever, and rear brake lever. (N) Rear springs. (O) Radiator fan. (P) Steering connecting bar. (Q) Petrol tank. (R) Steering gear. (S) Front axle. (T) Foot brake drum. (U) Detachable wire wheels. (V) Front wheels.

at the same time, being held fast by a brake-band. Since P turns in this direction it is evident that B must turn in the opposite direction, as indicated by the arrow within B. Consequently, B's teeth pressing against those of R (which are stationary) will tend to make B move along the inside of R in the direction shown; this will, of course, compel the arm (A) to advance in that direction also, as shown by another arrow.

As stated, P is keyed to the engine shaft, so, coupling the arm (A) to the road wheels by a clutch or other suitable means, we shall get A moving the road wheels at a certain speed. This gives the first speed.

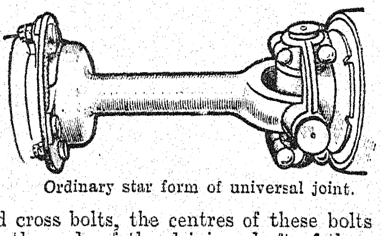
If now the brake-band on R be loosened, and the wheels comprising the gear are clamped or locked together, the whole will revolve en bloc in the same direction and at the same speed as the engine shaft. This is the second, and highest, speed. Again, if the arm (A) be disconnected from the road wheels and prevented from revolving (2)—P still turning in the same way—B still revolves in the opposite direction, as shown, and the teeth on B, pressing those on the inside of R, will cause R to revolve in the opposite direction to P, and also in the opposite direction to that of the two previous occasions. This, then, if R be coupled (similarly to the manner in which A was before) to the road wheels, gives the reverse. It will be seen that this single train of epicyclic gear obtains two speeds forward and a reverse

Spherical form of universal joint. A sphere slotted at right angles serves to connect the forked ends of the two shafts. This type provides much greater wearing surface, with smoother action, than the older forked type.



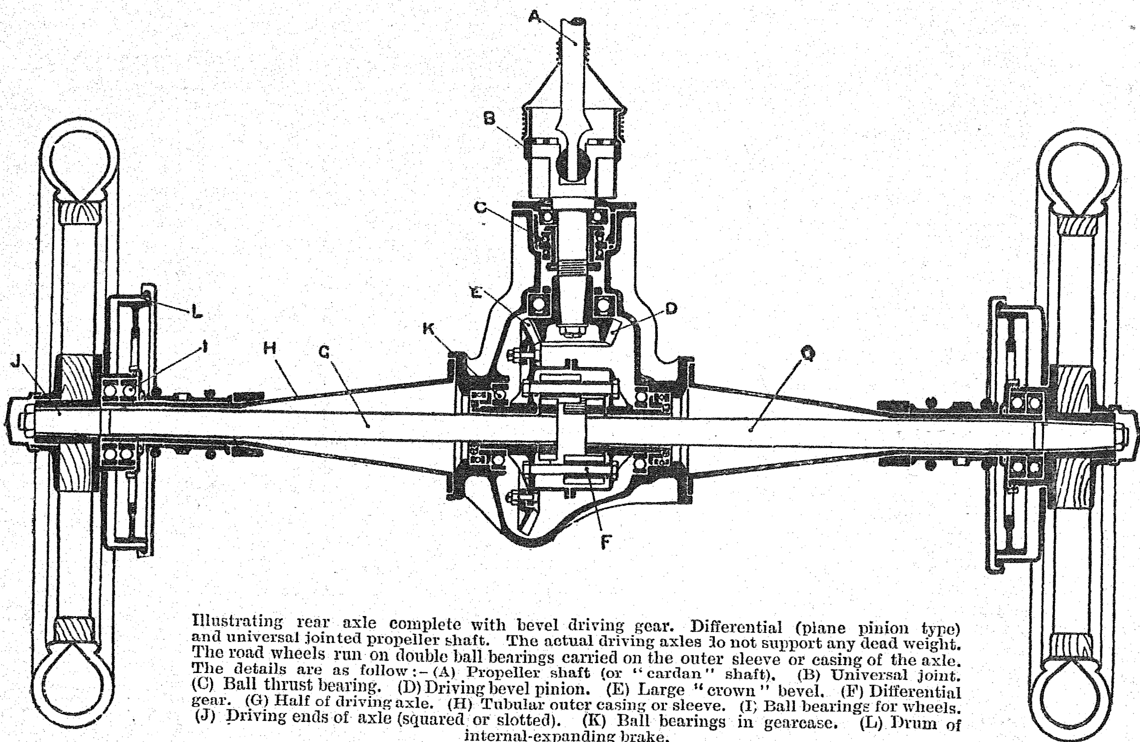
Propeller Shaft, Universal Joints and Torque Tube

The power, after passing through the gearbox, is thence transmitted by a propeller shaft fitted with flexible couplings or universal joints. This enables the power to be transmitted from the gearbox to the driving axle, the universal joints allowing the shaft to move up and down with the varying movements of the driving axle caused by the inequalities of the road surface. In the simple or "star" type of universal joint the ends of the shafts are provided with forks, in



Ordinary star form of universal joint.

which are fitted cross bolts, the centres of these bolts being pivoted in similar forks at the ends of the driving shaft of the gearbox and back axle. This system is sometimes termed a "cardan" shaft drive. There are many modifications of it in design. One usual arrangement is to encase the shaft in a sleeve. When uncased the joints are protected by leather covers. When the shaft is enclosed in a sleeve the latter is known as a torque tube because it serves to resist the torque or tendency to twist round of the rear axle. It also takes the "thrust" from the road wheels to the frame of the car to which it is anchored. This type has a universal joint at the gearbox end only.

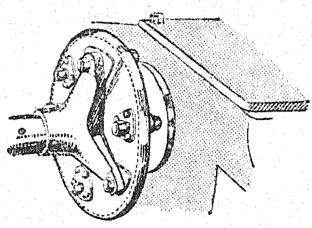


Illustrating rear axle complete with bevel driving gear. Differential (plane pinion type) and universal jointed propeller shaft. The actual driving axles do not support any dead weight. The road wheels run on double ball bearings carried on the outer sleeve or casing of the axle. The details are as follow:—(A) Propeller shaft (or "cardan" shaft). (B) Universal joint. (C) Ball thrust bearing. (D) Driving bevel pinion. (E) Large "crown" bevel. (F) Differential gear. (G) Half of driving axle. (H) Tubular outer casing or sleeve. (I) Ball bearings for wheels. (J) Driving ends of axle (squared or slotted). (K) Ball bearings in gearcase. (L) Drum of internal-expanding brake.

NOTE.—*The power is transmitted from driving bevel* (D) *to large crown bevel* (E)—*this being bolted to the case of the differential* (F)—*thence by the inside pinions to each half of driving axle. It is usual to "anchor" the outer casing enclosing the differential gear to the chassis by means of torque rods bolted to the upper and lower points of the gearcase which counteract the tendency for the whole casing to twist round from the reaction of the driving effort. On some cars the rear springs are made to serve as torque rods.*

Leather Universal Joint

Formerly used for auxiliary purposes, this is now being applied to cars of small and medium power for transmission, and is giving satisfactory results. In practice it is of very simple construction, and as there are no metallic parts in it subject to wear it is very smooth and quiet in working. Moreover, it provides an ample degree of flexibility, and it can be easily disconnected. It consists of two discs of leather placed together and of a thickness and diameter found suitable to the power to be transmitted through it. For a small car it may be ⅜ in. to ½ in. thick, and from 7 ins. to 9 ins. in diameter. The two drive shafts are attached to the leather disc by a three-armed plate, one bolted on each side of the disc, but with the arms of the respective plates set equi-distant from each other instead of directly opposite, thus taking the drive through the leather and obtaining the necessary flexibility.



Leather disc type of universal joint.

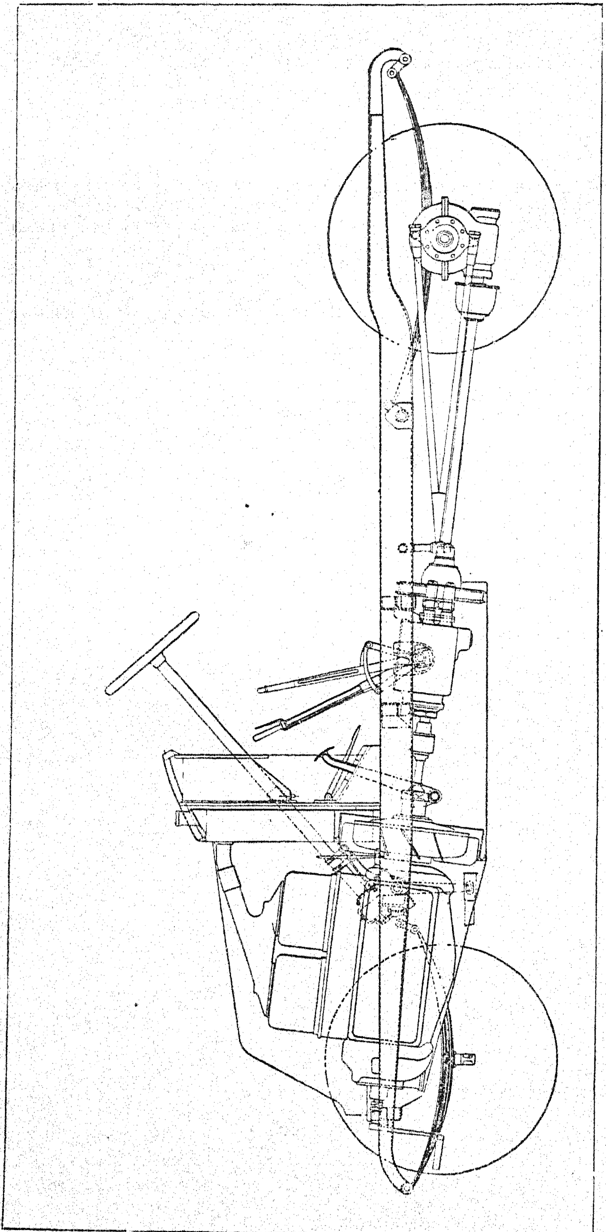
Rear Axle Construction

The rear axle is the most important part of the transmission, as it carries the greater proportion of the weight of the car, and at the same time transmits the power to the road wheels. It also has to take the strain of the brake action. The outer casing is a fixed tube supported by the car springs. At each end are arranged ball bearings. The power axle proper which transmits the drive is made in two parts connected in the centre by a differential gear, and at the extreme ends the road wheels are keyed. Ball bearings are arranged at the several places shown to reduce the friction. There are also provided two stiffening or tie rods below the axle case to prevent it bending under the stress or load. The dead weight of the car is borne by the outer casing of the axle.

There are several methods of constructing the casing of a rear axle. It can be built up of steel tubes and forgings brazed or welded together, but the best combination of lightness with strength would appear to be the use of steel stampings, the axle being made in two halves bolted throughout its length.

Combined Rear Axle and Gearbox

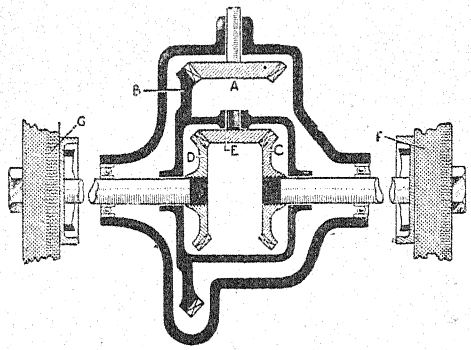
This practice is now applied to a number of the smaller and medium-powered cars. Formerly the system had the disadvantage of adding greatly to the unsprung weight, but modern methods and materials have greatly reduced this. It provides greater simplification in construction and perfect alignment of this part of the transmission, and as the gearbox is quite removed from the frame it is found that gear noises are much reduced. The control of the gears is effected by rods extending from the usual gear lever position.



A typical chassis with worm-gear drive, the worm pinion engaging the worm wheel from below. The engine is a four-cylinder with thermo circulation. The radiator being placed behind the engine provides maximum accessibility for the engine, magneto and carburetter. It will be noted that the engine is set slightly slant-wise in the frame. This enables a straight line drive to the rear axle to be obtained with a higher transmission efficiency.

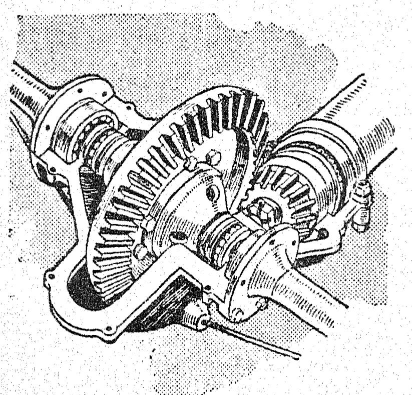
Theory of Differential or Balance Gear

This can be followed from the diagram of a very elementary form of the gear. Part A is the bevel driving pinion and shaft (connected to engine viâ the gearbox and clutch), B is the large crown bevel wheel driven by pinion (A). This crown wheel is bolted to a box or casing, which carries a bevel pinion (E), free to move on its centre. It gears simultaneously with two other bevel pinions (C and D), each of which is rigidly fixed to a shaft or axle, driving the road wheels of the car (F. and G.); each shaft can turn round in ball bearings (the



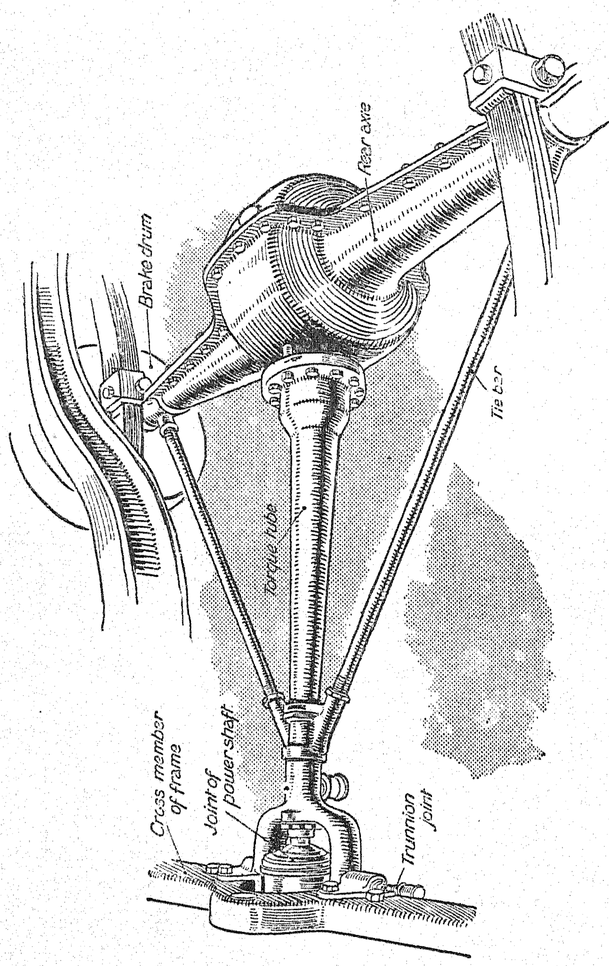
Simple diagram to explain action of differential gear.

break shown in the shafts is obviously only for convenience of sketching within limited space), but it must be noted that each driving shaft is *independent*, and is only connected by the bevel pinion (E). The outer casing, beyond the fact of it serving to carry pinion shaft of A, need not be considered in the working. If the car be travelling in a straight line, the differential box, with pinion (E), turns round



The power from the engine is transmitted at right angles to the rear axle and the road wheels by means of a bevel gear. This consists of a small bevel pinion meshing at right angles with a similarly toothed wheel, but much larger in diameter and known as the crown wheel. The ratio of the diameters of these wheels ranges from 3½ to 1 to 4½ to 1, and this ratio determines the "top gear" or direct drive of the car. The conical shaped box or casing in the centre of the crown wheel contains the differential gear. The thrust or pressure between the two bevel gear wheels is very severe and this thrust-friction is taken by the ball bearings which are shown.

"solid" with pinions (D and C), just as though the crown wheel drove the two road-wheel shafts direct. Immediately the car is steered so as to move in a circular direction, say, road wheel (F) has to move faster, owing to it taking the outside of the curve, the shaft pinion (C) will overrun the differential pinion, and thus allow the road-wheel



Back axle and triangulated torque tube

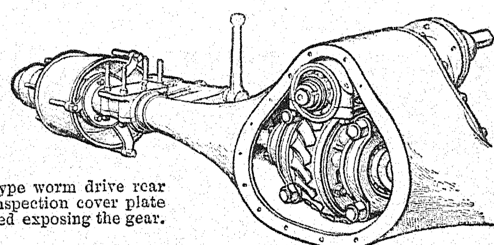
shafts to turn at different speeds, *although connected and driven by the pinion (E)*. The crown wheel (B), of course, is turning at constant speed. Only a single differential pinion (E) is shown, although, in a practical gear, three or four would be used, these being set equidistant around the differential casing.

Torque Reaction and Driving Thrust

The outer casing of a rear axle has a strong tendency to turn round as the result of the reaction of the driving bevel. This effect is resisted by carrying two rods or stays triangle-wise from the bevel gear-case to a point on one of the cross members of the frame. In many instances the cardan shaft is carried in a large diameter tube hinged to a cross member of the frame. The actual thrust or drive from the road wheels to the frame, and which propels the car, must be transmitted by some medium such as the torque tube, or springs from the casing of the rear axle.

Back Axle and Triangulated Torque Tube System

This method of construction is now much used. It is neat and mechanical and makes practically a complete, rigid, and well-protected unit of the rear axle with its torque tube. The power-transmission shaft is encased in the torque tube, which is bolted by a large flange to the rear axle at the bevel drive and differential casing. The torque tube gradually tapers, and then finishes off in a large forked end, which pivots on bearings attached to a cross member of the frame. This allows for the up-and-down movement of the back axle, caused by the inequalities of the road. The power shaft, of course, has a universal



Over-type worm drive rear axle inspection cover plate removed exposing the gear.

joint at the free end of the torque tube. The thrust is taken by the cross member of the frame. The alignment and rigidity of the system is further assured by the use of tie bars, which extend from points as nearly as practicable at the ends of the rear axle to a point near the end of the torque tube, to which they converge. Thus, what is termed a triangulated tie-bar system is obtained, and the rear axle is always maintained at right-angles to the torque tube.

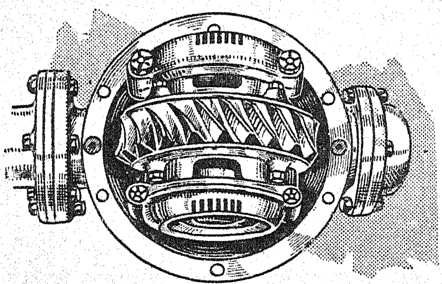
Worm-gear Drive

The system is used on a large number of cars now, and is coming more into favour every year. There is no difference in the transmission system, except as regards the drive, as compared with the usual bevel-gear system. In principle the worm drive is a simple arrangement: the usual bevel gear and pinion are replaced by a specially-shaped hollow helical-toothed gearwheel and worm, the latter engaging

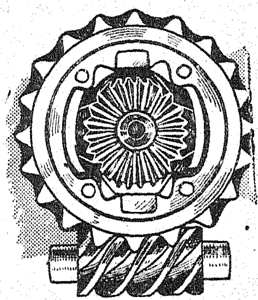
in the teeth of the gearwheel, the axes of the two shafts being at right angles. When accurately made, worm gear runs with great smoothness and silence. The worm may engage either from above or below the gearwheel. The angle of the worm and gear may be as much as 45 degrees. The worm is made of hard steel and the wheel of bronze.

The overtype gear offers the advantages of giving a straight-line drive from the engine, that is the transmission shaft has not to be set at so great an angle as to cause some loss of efficiency. It also enables a greater road clearance to be obtained at the transmission case of the rear axle. The undertype drive is, however, used to a considerable extent, a straight-line drive being obtained by setting the engine slightly on the slant from the forward end. One advantage of the undertype drive is that the worm runs continually in a bath of lubricant, which is so essential for this system of transmission.

A worm-gear drive, when scientifically designed, can show an efficiency of 97 per cent. with very little falling off after a long period of use. The weight and size of a worm-drive axle are no greater than those of a bevel gear axle for similar power.



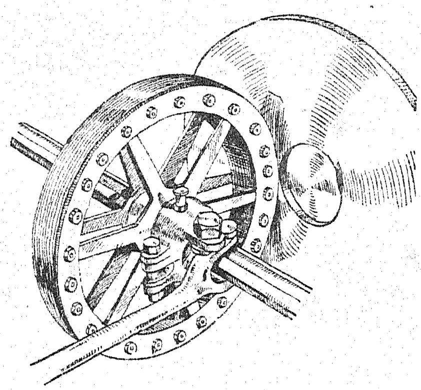
Under-driven worm gear. Top cover of casing removed.



Worm and worm wheel, with differential pinions complete.

Friction Drive

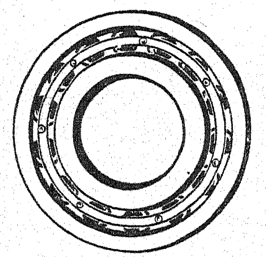
This is the simplest form of transmission applicable to motorcars. In principle it consists of a rotating steel disc of large diameter fitted on the engine shaft, and mounted at right angles to it is a friction wheel, the rim or edge of which is faced with fibre or compressed paper. The wheel is capable of being moved on a keyway right along the shaft by means of a forked lever. Sufficient pressure is provided by a spring to bring the disc and friction wheel into close driving contact. The countershaft will then revolve at a speed and direction depending on the position of the wheel relative to the disc. If at the exact centre, the speed will be zero, or nothing, and as it is gradually brought farther along towards the edge the speed will increase to a maximum. If moved right across to the other side of the disc the motion is reversed. By withdrawing the disc out of contact with the friction wheel, by means of a pedal or lever, the engine is left running free or in neutral gear. The whole arrangement, therefore, comprises a clutch and all-speed gear in forward and reverse directions. It is usual, however, to have a series of fixed positions for the contact of the friction wheel, so that the gear lever can be operated through a quadrant. Six or eight speeds can be usually accommodated.



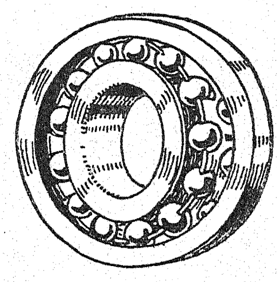
Simple form of friction drive with gear variable from zero to maximum.

Types of Bearings

To reduce as much as possible the friction at various parts of the transmission system, ball bearings of a special type are adopted. These are now fitted to various shaft bearings, road wheels, and to a small extent are adopted for the crankshaft and connecting-rod bearings of engine. The illustration (A) shows a standard type of ball bearing.

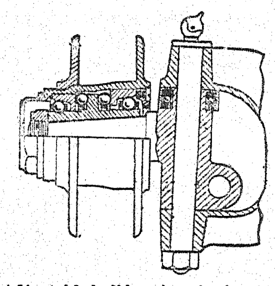


Type of ball bearing used for gearboxes and axles.

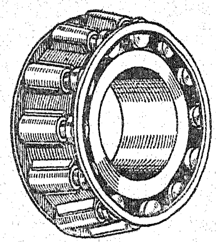


Self-aligning ball bearing. This type runs freely even if the shafts be not in true alignment. There are two rows of balls running in a curved ball race.

A ring of large diameter steel balls runs between a fixed outer steel collar and a rotating inner one, into which the shaft fits tightly. The balls are usually mounted in "cages," or else separators are fitted between each ball to prevent friction from the balls rubbing against one another. These bearings are made with extreme accuracy, and run with great freedom. They are also exceedingly hard and durable, so much so as to be practically unwearable, and thus no means for adjustment is necessary. The amount of lubrication required is nothing like so great as with a plain bearing, and when well protected from dust it requires very little attention. Roller bearings are also used to a considerable extent. One form of construction consists of a set of

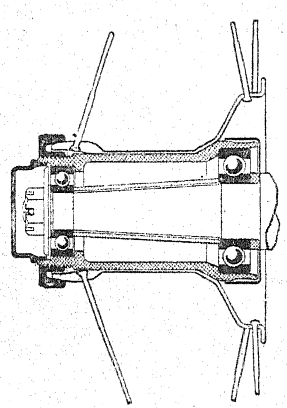


Adjustable ball bearings for front wheels taking side thrust and load.

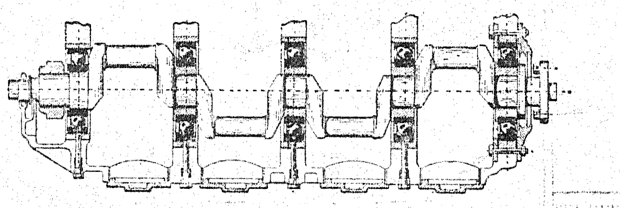


Roller bearing for load and end thrust.

hardened steel rollers mounted freely in a metal cage, the shaft passing through the interior. The roller bearing takes the load on a line contact, whereas the ball bearing has point contact.



Ball-bearing mounting of a front detachable wire wheel. The bearings are made on a similar principle to those shown in left sketch on page 88.



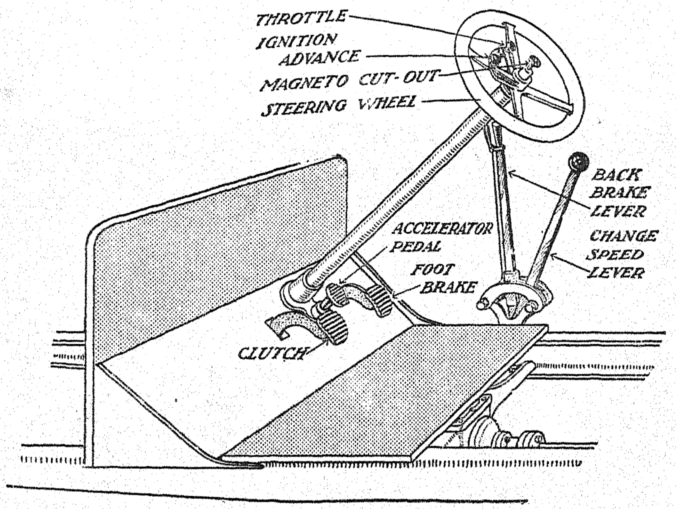
Ball bearings applied to crankshaft of four-cylinder engine.

The durability of ball and roller bearings largely depends on thorough protection from access of grit and water, which quickly cause pitting or rusting. It is usual to fill the bearing up with grease, and it should be kept in this condition. Particular care should be taken that the grease or other lubricant used is perfectly pure, as any trace of acid or alkali would cause corrosion.

CHAPTER VI

Control Devices : Brakes : Silencers

The control of a car comes broadly under several headings: (1) Starting and stopping, (2) regulation of the speed, (3) steering or direction of movement. The actual starting and stopping of the engine are best considered apart from the actual control of the car. (1) This is effected by the clutch and brakes, both operated by pedal, conveniently placed on the right of the footboard. What may be regarded as the emergency brake is operated by a hand lever on the right-hand side of driver's seat. (2) The throttle, admitting more or less of the explosive mixture to the cylinders, this partly under pedal and partly under hand control on the steering wheel. The change-speed gear, effected by hand-lever control, operates in conjunction with the throttle. It provides three or four speeds, which enables the engine power to be used to the best

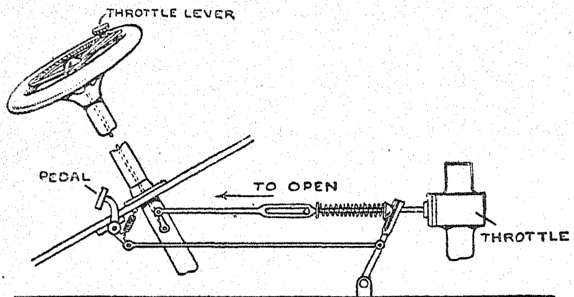


Car control system in detail.

advantage, according to whether the road is hilly or level. (3) The steering control by hand wheel is so obvious as not to require further reference. A reversal of direction of the car's movement is obtained by use of the "reverse" speed in the change-speed gearbox and controlled by the same lever.

Hand Throttle Lever: Accelerator Pedal

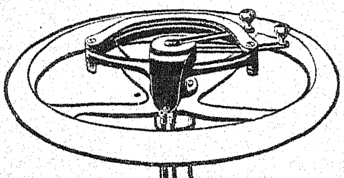
The throttle is the main control over the speed and power of an engine, as by the use of it the amount of mixture which can be drawn into the cylinder is thereby regulated. The proportion of air to petrol in the mixture is kept constant by the carburetter. Control by advancing and retarding the spark is only of very limited value. Many cars have the ignition timing fixed, as this simplifies the control. In ordinary circumstances retardation is only required for starting up and to prevent engine knocking on hills. For all average running the spark is kept advanced. Some range of timing control is, however, desirable as a better all-round efficiency can be obtained by varying the spark timing according to the driving conditions. Although an engine can be controlled by a simple hand lever on the steering wheel, it is now usual to have an additional control by an accelerator pedal, as in the



Hand lever and accelerator pedal control of throttle. Diagram of principle of the arrangement.

diagram, which clearly shows the arrangement. The speed is set to a fixed amount by the throttle lever, and then if more speed or rapid acceleration is required the pedal is depressed and the throttle opened to a proportionately greater extent. For driving in traffic the pedal accelerator is particularly useful by reason of the easy control it provides, the throttle lever being set to keep the engine running at a slow speed without noise or vibration when declutched.

In a few cases the pedal is arranged to "decelerate," that is, to close the throttle to a certain point on depressing the pedal. The use of the term "decelerate" is open to criticism; strictly speaking, the



A usual arrangement of control levers on the steering wheel. The connections to the throttle and ignition, *i.e.* magneto timing rocker, are made by Bowden wires.

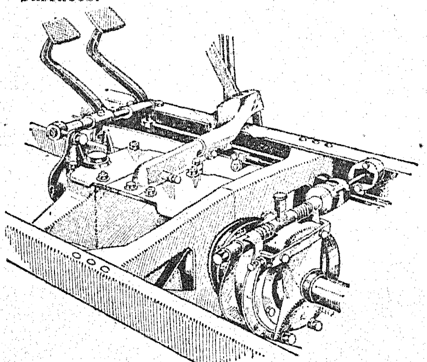
action is only a reverse movement of the pedal. In this case it does, in the upward movement, what it previously did in a downward movement.

The throttle lever movement on some cars enables air to be admitted to the cylinders. When the "shut" position is reached the lever can be moved further a small extent, and an air port on the inlet pipe or carburetter opened. This provides engine-brake effect without risk of oil being drawn past the pistons, as no vacuum is produced in the cylinders.

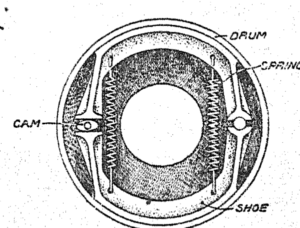
Brakes

The types of brakes in use differ considerably in detail, but in principle conform to either the band or expanding shoe type. The contracting shoe type is a variation of the band type.

In the simple form of band brake a steel band, preferably lined with a special non-charring material composed of woven asbestos and brass wire, encircles a metal drum fixed to the hubs of the driving wheels. The bands are tightened on the drums through the agency of cables or rods connected up to the brake lever at the side of the car. Another brake is arranged so that it can be actuated by pressing down a pedal. This brake is the one which is most conveniently manipulated. It acts on the countershaft, and the main or side brakes are only used as emergency brakes or for holding the car on a hill. Rear brakes always have a "compensating" action; which ensures that the pressure applied by the hand lever or pedal is divided equally between the two brakes. This is very important for safety in driving, as unequal brake action is a cause of skidding on greasy surfaces.



Type of countershaft brake with outside shoes, provided with a quick adjustment. The connection to the right-hand pedal is also shown.



Arrangement of internal-expanding brake. The cam is operated from the brake lever.

Brake mechanism acting direct on the rear wheels is usually of the metal-to-metal internal-expanding type in which "shoes" of bronze or cast-iron are caused to press on the interior of a metal drum bolted to the wheel, and as arrangements are made for efficiently lubricating the surfaces, great retarding pressure can be exerted without undue wear on the metal.

It is not unusual to find a brake of the internal-expanding type used for the countershaft, and some makers go so far as to have two metal-to-metal brakes working on the same drum, one inside and one outside usually, arranged to run in an oil bath, thus ensuring smoothness in working with a minimum of heat produced and less wear and tear resulting.

Double Braking on Rear Wheels

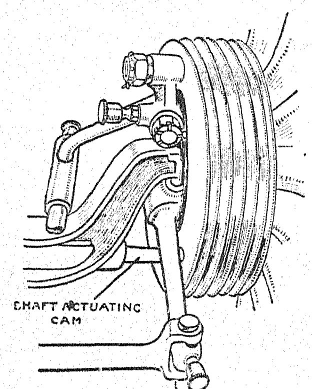
A practice which is extending in car design is the elimination of the countershaft brake and the use of extra brakes on the rear wheels, i.e., a pair of brakes acting outside the usual brake drums but operated by a pedal, the side lever operating the internal brakes. This arrangement simplifies the construction and relieves the transmission of braking strains.

Engine or Compression Brake

In addition to the friction created in the engine due to the rubbing of the pistons against the cylinder walls, by converting it into an air compressor by the simple operation of admitting air, it forms an excellent brake, which cannot overheat, as it is water-jacketed. For this reason, when descending a long hill to avoid risk of overheating the main brakes, the lowest gear may be put in action—this will create the maximum amount of bearing friction—and it will cause the engine to work as a very powerful and smooth acting brake, geared up, as it is, to considerably more than its normal rate of revolutions.

Braking on All Wheels; Diagonal Braking

What is termed diagonal braking is now used to some extent, and this principle has proved a very satisfactory one in preventing the skidding tendency on greasy roads when the brakes are applied. In this system a brake is fitted to each of the four wheels, and these are all applied simultaneously and with equal force, but the direction of the pull on each pair of brakes is diagonal, i.e., from an off-side front to a near-side back wheel, and vice versa.

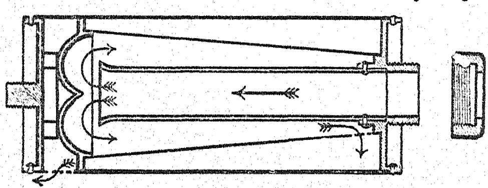


Front wheel brake arrangement and enclosed steering pivot.

Silencers

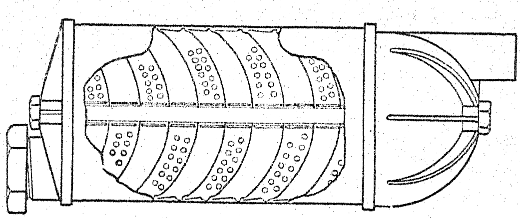
At the conclusion of the explosion stroke the gases are, at a pressure of about 40 lb. per sq. in., and if ejected directly from the exhaust port into the air a loud report would be caused; hence it is necessary to "silence" the exhaust.

The principle of a silencer is to provide a chamber or box into which the exhaust gases can pass and expand as much as possible before coming in contact with the atmosphere. The greater the pressure of the exhaust gases the more noise will be made by impact with the



Concentric tube silencer.

air; so, to obtain effective silencing, means must be adopted to diminish this pressure as much as possible. This can be effected by having a cylindrical sheet steel or aluminium box of considerable capacity, depending on the size of the engine, inside which are arranged baffle plates for the gases to impinge upon. Or there may be a series of inner tubes perforated with very small holes: the expanded gases pass through these holes, and thence into the atmosphere at a much reduced pressure. One of the simplest types consists of three concentric tubes, the inner one being much smaller than the outer one, which forms the main expansion chamber. The gases enter by the central tube, pass through and strike the curved base of the cone-shaped casing, and are thus deflected upwards and finally pass into the atmosphere through the holes in the outer casing.



Type of silencer consisting of a series of perforated dome-shaped chambers placed one inside the other, and which effectually silences the exhaust gases which take a zig-zag course through the baffles.

Illegal Use of Exhaust Cut-out

A well-designed silencer should offer very little resistance to the passage of the exhaust, and it is a mistake to assume that an open exhaust obtained by using a "cut-out" device increases the power of the engine. The use of this fitment on the road is now illegal, owing to the alarm caused by the unsilenced discharge of exhaust gases. If used at all, it should be strictly limited to the repair shop or motor house, to see if all the cylinders are firing properly. It is very important that a silencer should be kept free inside from carbon or mud, which, by choking the exhaust, reduces engine power. All well-designed silencers can be taken apart for cleaning the apertures in the baffle plates or tubes.

Exhaust Pipe Connection to Silencer

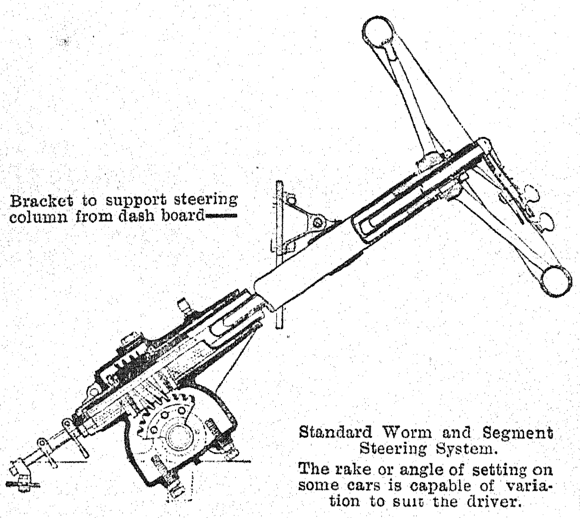
Although a silencer may produce a minimum of back pressure it may have its advantages more or less nullified if the exhaust pipe connecting it to the engine be not suitably designed and arranged. That is to say, a pipe of small diameter having several bends in its course to the silencer may offer a lot of resistance to the free passage of the exhaust gases. On modern cars this fault is not usually met with, the exhaust pipe being at least as large as the exhaust valve diameter and free from sharp bends. Some of the older cars, however, are not well designed in this respect, hence in fitting a new silencer it is often advisable to alter the exhaust pipe.

CHAPTER VII

Steering Gear, Frame, Wheels and Bodywork

The Steering System

The modern system of steering is on standardized lines, and very little variation will be found in the principles adopted on any make of car. The steering column and hand wheel are much more "raked" or inclined than previously, and as the engine control rods are generally taken down the inside of the column the steering is kept free from exterior fittings, and thereby is neater in appearance. The steering system consists of a pillar or shaft mounted and passing up through a hollow standard on the floor of the car in a considerably inclined position and within easy reach of the driver. The upper end terminates in a large hand wheel, and the lower end is connected by a simple piece of gearing to rods which move the front wheels together, the wheels being mounted on short axles which are cross connected by a tie bar.



Standard Worm and Segment Steering System.
The rake or angle of setting on some cars is capable of variation to suit the driver.

The details of the system will be better understood by a reference to the illustration. At the end of the shaft is a worm or quick thread, engaging in a toothed quadrant; this is mounted on a short shaft, which carries an arm that is connected up to one of the steering axles by a ball-jointed rod. The two wheel axles being also connected together, it will be seen that when the steering wheel is turned the screw or worm causes the quadrant arm to push the connecting rod backwards or forwards, and this motion is conveyed to the two wheels, these being connected by a bar with forked end joints to give free movement. This system is irreversible, as road shocks cannot cause any relative movement

Steering System

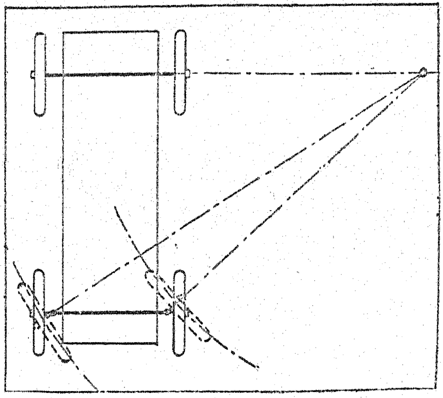
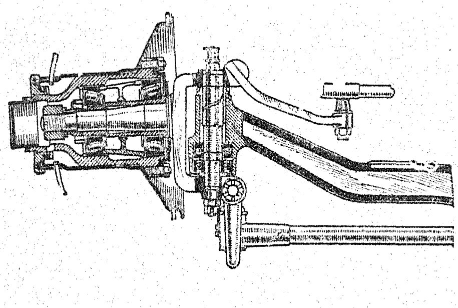
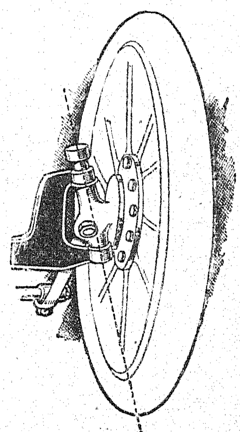


Diagram of geometric principle of setting the steering arm mechanism, so that lines drawn through the wheel axles and projected intersect the rear axle line extended. Each wheel is separately pivoted, but linked together at the steering arms so that whichever wheel is on the inside of the steering circle turns through a wider angle than the outer wheel does. Each wheel is thus always tangential to the circle it describes.



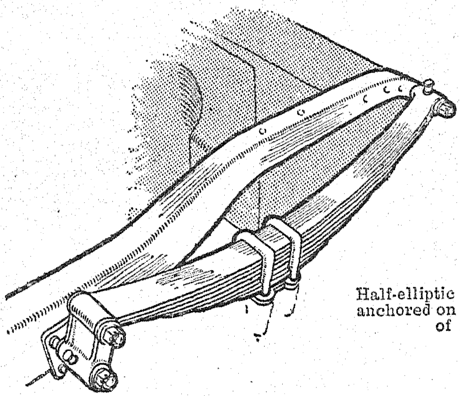
Details of front axle with steering arms. It should be noted that the arm to which the tie bar connecting the two wheel axles is fitted moves in a horizontal plane although drawn in a vertical position. It is dropped slightly and bent at right angles. A roller bearing hub for a detachable wire wheel is shown in position.



Principle of inclined or self-centring steering head in which the line of the steering axis coincides with the point of wheel contact with the road. This system gives very easy and sensitive steering.

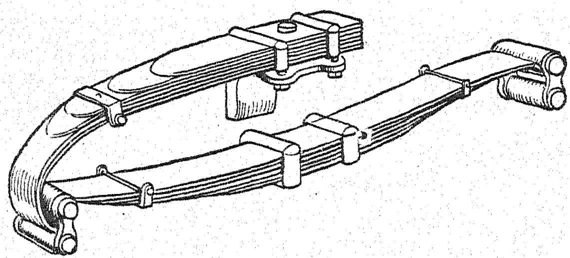
between the worm and quadrant; and thus the driver has complete control over the steering with the minimum of effort.

After a considerable period of use, back lash or lost motion is often very pronounced in some cars having the worm and quadrant, and it is



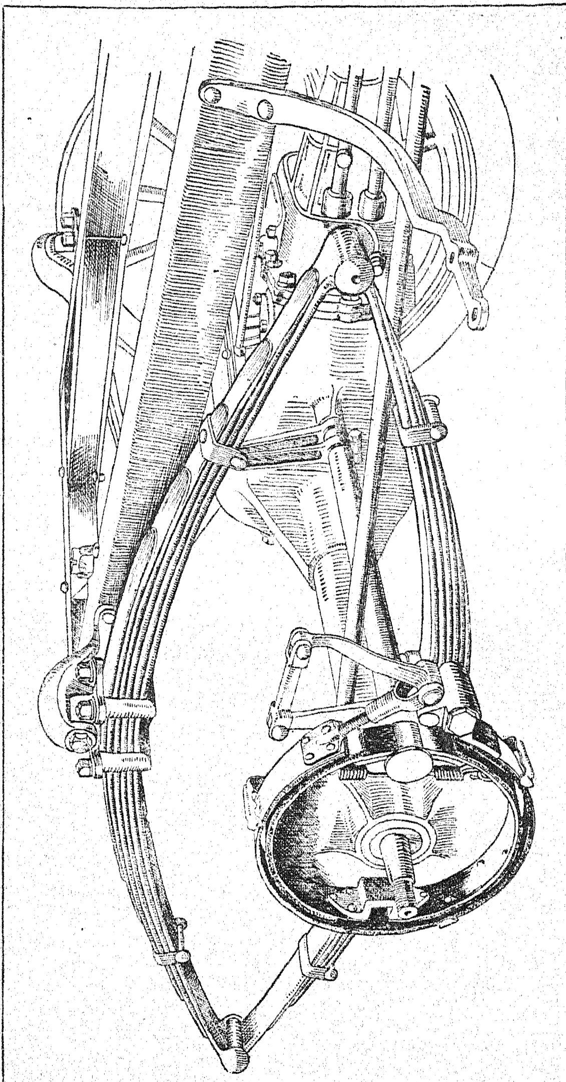
Half-elliptic rear spring anchored on pins on end of frame.

difficult to remedy it except by fitting a new quadrant, unless some means of adjustment has been provided, such as an eccentric bearing to bring the quadrant teeth closer to the worm. A plan now adopted is to provide a complete pinion instead of a quadrant, so that when one set of teeth is worn a new set can be brought into use by moving the



Type of spring as fitted to rear axle, known as three-quarter elliptical.

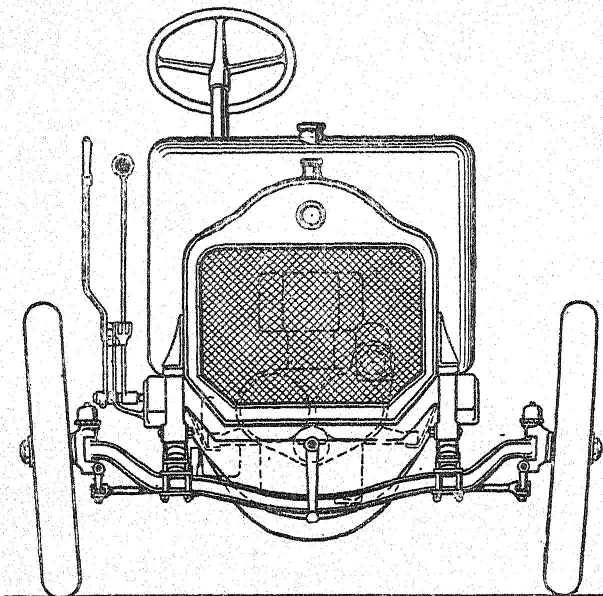
pinion round by a quarter turn. Looseness of the steering wheel obviously lessens the responsiveness of the road wheels to the steering mechanism. To get perfect steering the two wheels must be coupled in such a way that, however much they are turned, the axis of each, if projected, will meet on the centre line of the rear axle. This point where the imaginary lines meet determines the centre round which the car will rotate. The two steering wheels must, in turning out of the straight line, be tangential each to its own track, and to attain this they must move together. The steering arm of each wheel is set in at a particular angle so that, when connected by the tie-bar it will fulfil the theoretical conditions stated. The wheels must always retain their parallelism in plan and to enable this to be effected on some cars an adjustment is provided on the tie-bar to lengthen or shorten it.



System of full elliptic rear springing. This illustration also clearly depicts a combined gearbox and rear axle and double-acting brakes, viz.; band brake on outside and expanding ring on inside. The brake drum is not shown, as this forms part of the wheel which has been removed from the axle end shown.

Front Axle

This important component is now always made from a steel forging of H section slightly curved or bow-shaped, which form gives a maximum of strength for a given weight and section. The ends of the axle terminate in a boss which is bored to carry the centre pivot, upon which the wheel-carrying axles can move freely. In some designs the axle ends terminate in a jaw-shaped piece, the wheel axles being of a design to correspond. The tubular front axle is only made to a limited extent. To support the springs a small platform or face is forged on the axle at the required positions.

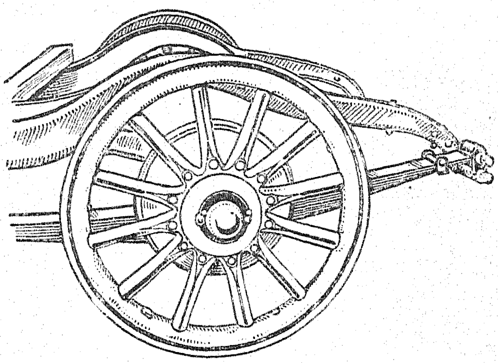


Front elevation of small car showing disposition of engine, magneto, radiator and tank, dashboard, spring suspension, steering pillar, front axle and wheels.

Chassis Framework: Sub-Frame and Three-point Suspension

The great majority of frames are made from pressed steel sections, or "members" specially shaped to resist the various bending and twisting strains, the middle part being deeper and wider than the ends. The frame so constructed is a rigid and light one. Another method is to have the frame completely pressed out of sheet steel. In this it is possible to press out the sheet in such a manner as to form a protecting apron or underscreen for the whole of the mechanism, which is thus cased in and thoroughly protected from the effects of mud and dust. There are, of course, no joints in this class of frame. In the ordinary frame the various sections are riveted together. Many modifications are introduced in frame design according to the arrangement of the transmission. Very often the gearbox and engine are mounted on a sub-frame, this being suspended from the main frame at three points to avoid undue stresses on the latter. To allow of a

considerable "lock" on the steering wheels for turning the car in a small circle, frames are inswept or narrowed considerably at the front. An "upsweep" at the rear is often met with, especially on large cars. The side members of the frame are tapered, the greatest depth being towards the centre, where the greatest bending strain occurs.

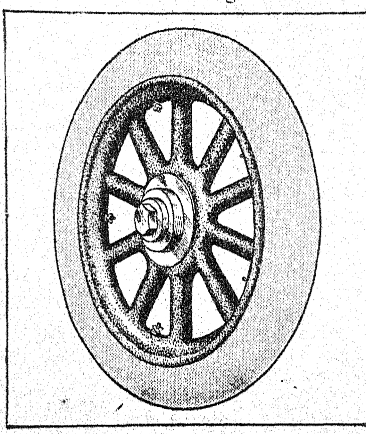


Example of underslung semi-elliptical spring, upswept frame and detachable wood wheel. Springs fitted under the axle.

Springs and Wheels

The body and frame are insulated from the road wheels by the springs, which absorb the heavier road shocks and vibrations, the pneumatic tyres absorbing the smaller vibrations. These springs are built up from laminated steel plates, which have been carefully hardened and tempered. These are either elliptical, semi-elliptical or straight, and supported by hinges or shackles in brackets bolted to the under side of the frame to allow for the lengthening and contracting of the spring. A transverse spring fixed in the centre is often used to carry the two rear side springs. This gives practically a three-point spring suspension.

The wood-spoked wheel, formerly known as the artillery wheel, is mostly adopted, as it is very strong laterally, and not easily knocked out of truth. Another advantage is that the amount of work entailed



All-metal wheel made from two pressed-steel sections welded together. In appearance it is very similar to a wood wheel but has distinctive advantages.

in cleaning is less than in the case of a wire wheel. This latter type is susceptible to the effects of rust on the spokes unless the enamelling is carefully done. On the other hand, a wire wheel is lighter than a wood wheel, and unaffected by climatic changes, and is being used to an increasing extent. In the construction of an artillery wheel the rim of the wheel and hub are not set exactly in line axially, but the rim is dished outwards by setting the spokes at a slight angle. This arrangement gives the wheel greater lateral strength than it would have if vertical spokes were used. The steering wheels are usually set slightly inwards at the road line. This brings the spokes vertical, relative to the road, and the weight is supported in a direct line. The fact of the steering line also approximating to the line of wheel and road contact makes the steering easier. All-metal artillery-type wheels are now adopted to a considerable extent. This type consists of two parts or sides pressed out of sheet steel and welded at the central joint. It combines most of the desirable features required in a motorcar wheel. It is unaffected by climatic changes, and is as easily cleaned as the wood wheel. It is practically indestructible by shock, whilst at the same time it is comparatively light in weight.

Bodywork

The elimination of many diverse types of bodies and the approach to something like standardization in outline has been one of the marked features of car development of the last year or two. Ugly and unsymmetrical bodywork is rarely met with even on the cheapest of cars. Greater attention has been paid to the provision of ample seating room and a comfortable position for the driver and passengers. The ordinary two-seater has plenty of room, even for occupants of more than normal dimensions, and the small, open car can seat four and, in many cases, five.

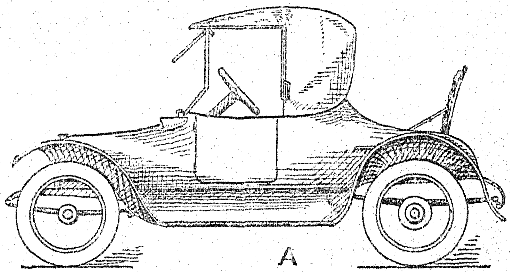
The changes of fashion modify outlines but cannot affect the general dimensions of motor carriages, nor alter the requirements of users. The two-seated cars are divided between the open car with hood and the enclosed coupé with a window in the quarter, the roof and rear part folding down, all the windows dropping into the framework, the front remaining fixed and supporting the roof. Illustrations of these two types are given in Figs. A and B.

There is a considerable difference, however, between these types and the similar ones of some years ago. The use of beaten metal panels is increasing, and as the possibilities of the artistic treatment of the somewhat necessarily formal outlines of the motorcar are developed, car bodies are assuming different shapes in many respects. For instance, cars of the type of Fig. A have the panels beaten out of two sheets with only a centre seam, the scuttle dash being in one and the doors being practically very slightly shaped. Wooden framework is used.

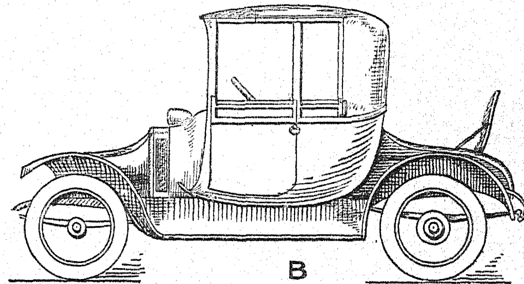
Fig. B. is a style suited to the requirements of medical practitioners, and seats three persons. The full rounded panels enhance the graceful lines of the design. Fig. C is the generally-accepted design of touring car. The lines are modified and sometimes exaggerated to suit individual tastes, but this may be said to be the prevailing style for all sizes.

A motor carriage which has been developed during the past two years is the saloon (Fig. D), a modified all-enclosed touring car to seat from four to seven persons, with only one door in each side and no division between the front seat and the usual interior seats. It forms one of the most sociable of cars for small or large parties. The front seats are made separately, the near side sliding forward or folding up to the side to permit of entry to the driver's seat, which is

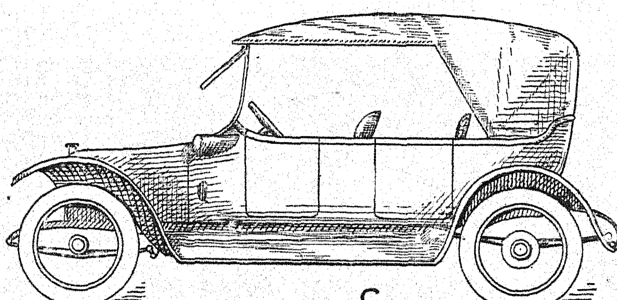
Standard Types of Coachwork



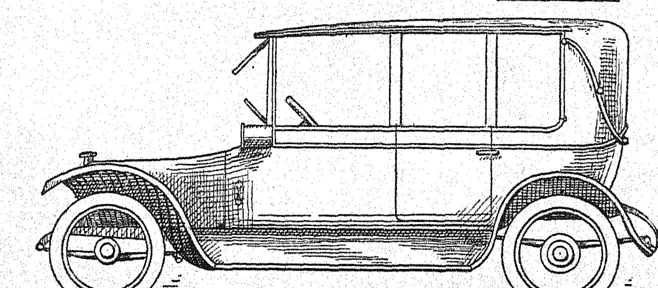
A



B

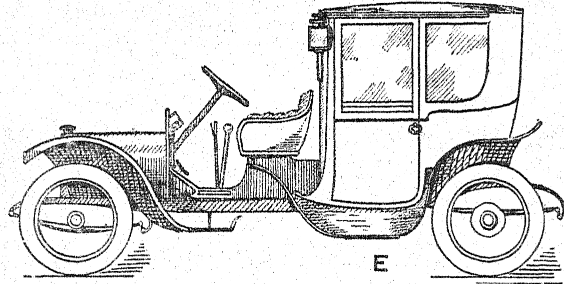


C

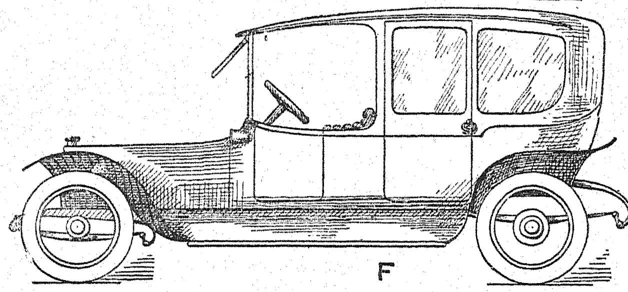


D

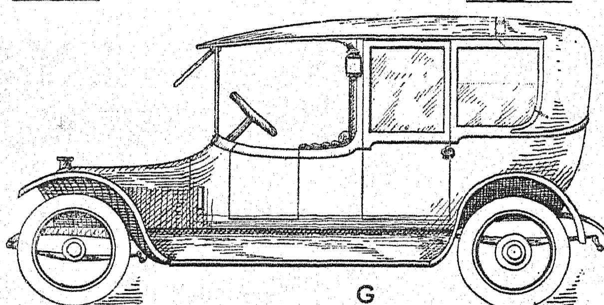
Standard Types of Coachwork



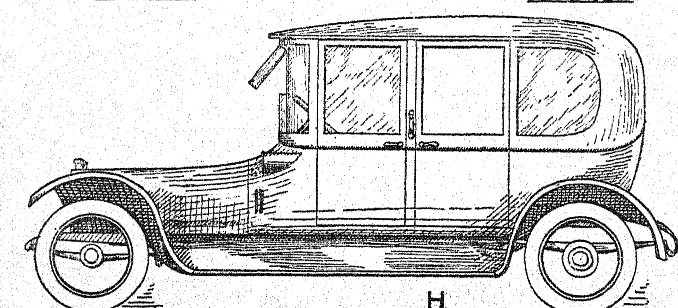
E



F



G



H

adjustable as to leg length and height. The roof is made either to fold entirely open or only the rear quarter, or as an entirely closed car, the bonnet and scuttle dash running into the body lines without any abrupt step.

When the car is made for four or five persons, and on a chassis of such a length that all the seats are within the wheelbase, a very comfortable and convenient carriage is produced.

The changes of fashion in chassis have produced a change in some designs of carriages, and the latest French design is a brougham to seat three or four persons. There have been numerous attempts at a satisfactory design for a motor brougham; the great improvements in engine power, the increased length of wheelbase and track, have resulted in the production of a chassis on which a well-designed body can be placed, and quite a number have been produced on the lines of Fig. E.

Larger wheels are now used than was the former practice, with great improvement to the appearance. Some cars have a folding hood and windscreen, but the most effective town carriages are without these; and are more in keeping with the limousine type of carriage (Fig. F), which is the latest type developed.

Berlin is accorded the palm for initiating the domed roof and rounded end of this design of limousine, and if artistically treated, and the purpose for which it is to be used kept in view, there are great possibilities for artistic treatment. The great advance in the manufacture of suitable aluminium sheets and of welding the joints has enabled designers to disregard the exigencies of space and the limitations of the application of curves to motor-body design, with the result that it is possible to develop new lines and practically to change the appearance of cars which had become familiar. The combination of a rigidly disposed front with a folding rear position of the roof as depicted in Fig. G, remains a favourite form of motor carriage.

Great improvements have been made in the fitting of the hood joints and the adjustment of bearing parts, so that there is very little difference in the appearance of the hood of a landaulet and of a limousine.

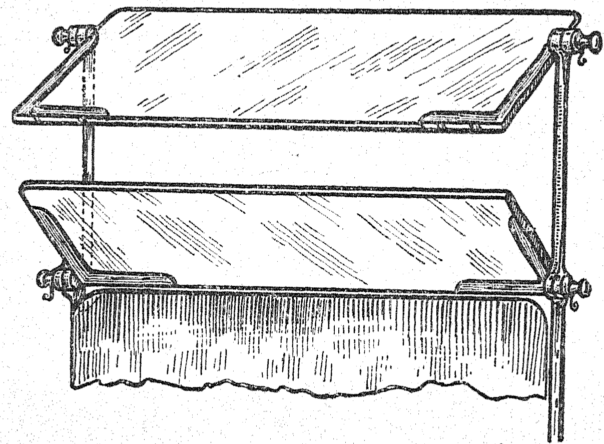
The All-enclosed Car

The largest type of motor carriage is the fully-enclosed front driving seat limousine, with doors to the front and to the rear compartments as shown in Fig. H. This type of carriage has been recently further developed, and a very complete design embracing the lines of the long six-cylinder bonnet, long mudguards, etc., has been evolved. The domed roof and rounded back are judiciously employed, and the front, instead of being left of great width and straight across, is finished with D-shaped glass and a folding-out upper part of the screen, giving a very novel effect to the whole. Beaten and welded aluminium panels play a large part in the production of these designs.

The most notable alterations and improvements in the design of motor carriages have been due to the improvements in the form and finish of the chassis, longer wheelbases, greater width of track, larger wheels, improved shape of the mudguards and their fittings, the shape of the radiators and inclination of the bonnet, and the merging of the lines of the scuttle dash and body, the fitting of special "post lights" for the side lamps, and provision of scuttle ventilators as standard. The steering columns of chassis intended to be driven by servants are not set at so acute an angle as are the touring cars, and greater room is given to the seating in consequence.

The fitting of the frameless glass to the doors and quarters has been greatly improved, and the use of these windows is now nearly universal.

There are many arrangements made and patented for raising, lowering and securing these windows, some of them most ingenious. The silencing of doors and movable parts is carried further than ever before. A noticeable feature in many new designs is the arrangement for carrying a spare tyre or steel wheels, in a compartment in the rear, the rearranged chassis and the use of higher seats in the rear making this feasible without the disfigurement of the design. On some of the latest designs of limousine the side lamps have been placed on the standing pillars with good effect. These pillars are often made of special shape and width, so that the occasional seats fitted to the fronts are partly recessed behind the opening of the doorway, and consequently do not protrude in the way of the entering passengers.



Windscreen with double adjustable panels. The opening gives the driver a clear view when driving in wet or snow.

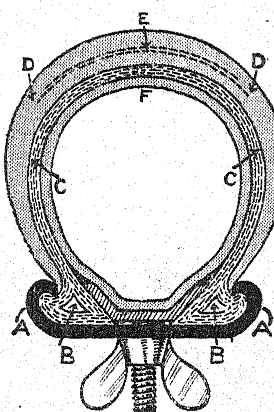
Hoods and Screens

The Cape hood, made in various kinds of proofed fabric and folding up into a small compass, is both light and efficient as a protection against the weather. The sides can be closed by curtains or left open as desired. The opening of the hood can be effected single-handed in certain forms, although the ordinary hood does not present much difficulty in manipulation to open or close it. Windscreens are made in a very large variety with single or double panels, either of which may be adjusted to any desired angle. Glass still remains the most used material for screens by reason of its transparency and the ease with which it can be kept clean. Celluloid, in one or other of its forms, or a material named exonite, can also be used, and the risk of breakage as obtains with glass is avoided. Exonite is an improvement on celluloid, insomuch as it is non-inflammable, and is practically as transparent as glass. The combined advantages of both glass and celluloid for windscreens can be obtained by the use of a special form of glass sheet made up of two plates of glass with thin celluloid cemented in between. This is practically as clear as the best glass, and is proof against actual breakage, that is to say, if struck by a missile it will simply "star" or develop a series of cracks, and no pieces will break away. Another form of glass which is safer than the plain sort is that known as "wired glass," which has wire netting embedded therein.

CHAPTER VIII

Tyres, Detachable Rims, and Wheels

Pneumatic tyres are universally used on all cars for touring and general use. For heavier vehicles, travelling at slow speeds, some form of solid tyre, sometimes used in conjunction with spring wheels may be used. The beaded-edge tyre is the standard system, and it will be seen from the diagram has the edges of the rim formed into channels (AA) to take the beads (BB) of the outer cover. This cover is composed of the fabric (a specially-woven canvas, or a rubber-proofed cord) CC, and the rubber (DD) thicker at the tread than at the sides. A fabric



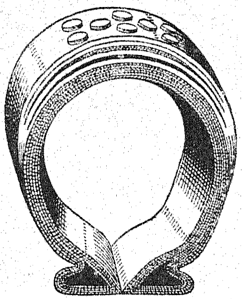
Sectional view of beaded edge pneumatic tyre, with plain round tread. The security bolt with its wing nut is also shown.

reinforcement is provided at E. The air tube (F), fitted with a non-return valve, is of a special thickness, moulded to circular shape in some cases, and the joint vulcanized. The air pressure forces the beads of the cover into the channels or "clinches." The covers are additionally secured to the rim by the use of holding down bolts or "security bolts," which serve to hold the beading of the cover firmly in place, and prevents the cover "creeping" round on the rim. The diagram shows how this is effected. Tyres are inflated to air pressure ranging from 50 to 120 lb. for ordinary use according to the size of tyre and the load carried

Non-Skidding and Puncture-Proof Devices

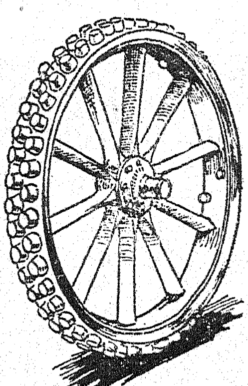
To minimize the risk of a car skidding on greasy roads numerous devices have been introduced. The most popular of these is the steel-studded leather band, which may be either permanently vulcanized on to the tyre or secured mechanically, as by straps passing under the rim, which type is known as a detachable non-skid. The steel studs

give the tyre an effective grip, whilst the toughness of the leather renders it proof against puncture. Another device is that in which steel chains supported by rings encircling the rim lie across the tread of the tyre in zig-zag fashion. A further arrangement consists of a jointed steel armour plate band on the tread. The band is formed of a series of links hinged together and secured to the wheel by straps fixed at intervals under the rim. Some makers now construct their tyres



Ordinary leather and steel stud non-skid band. The extra running tread is now often dispensed with and one vulcanized leather tread fitted over the rubber.

with the steel studs vulcanized permanently in the rubber tread of the cover. When it is desirable that the resiliency of the tyre should not be diminished by the addition of leather or metallic bands to the cover, most of the best-known makes of tyres can be had with non-slipping treads.



A special non-skid semi-solid tyre, consisting of large studs of rubber carried in a special rim. Each stud has an interior air space for cushioning effect.

The rubber may be moulded in a special form, having corrugations or ribs to get a firm grip of the road. These treads are not so effective as sideslip preventers as the steel-studded cover on all forms of road surface, but are distinctly better than the plain, smooth tread. The variations in actual design of moulded non-skidding treads are very numerous. Each type has some particular merit claimed for it.

The "chain" non-skid, which can be attached when required, is probably the simplest device, and very useful when plain-surfaced tyre covers are used. The steel chains are arranged in zig-zag fashion across the surface and fit loosely, so that the whole device can creep round the tyre when in use. A form of tyre which gives very favourable

results has studs or projections of rubber moulded as part of the cover. The term "all-rubber non-skid" has been applied to this form of tyre. It is durable, resilient, and little inferior in its non-skidding properties to steel-studded covers. Other devices not forming part of the tyre have been adopted with more or less success. One of these simply consists of a steel chain hanging loosely on the road, and on the inside of the wheel, and close to the tyre, so that any sideways motion of the wheel results in the chain being trapped under the tyre and thus checking the skid. The detachable non-skid bands which either grip by a series of plates under the lips of the rims or are fixed by mechanical means, such as clamps or contracting steel rings, are largely used for plain tyres.

Degree of Inflation

The air-pressure plays an important part in the life of the tyre. Each tyre requires a definite air pressure in relation to its strength and the weight it has to carry, and this pressure should be rather too high than low. Insufficient air pressure destroys the cover, as the weight which it has to carry causes it to flatten out, the fabric becomes loose and is damaged through the friction thus set up, so that the life of the cover is considerably shortened. On the basis of many years experience, the following is a table of the air pressure which tyres of different dimensions ought to have, keeping in view the weights they have to carry:—

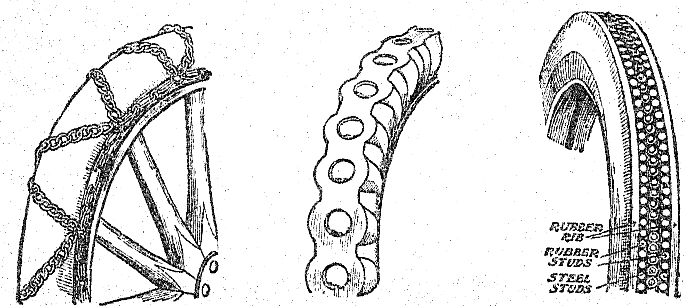
Diameter or Cross Section.	Total weight, including passengers, luggage, &c., per axle = 2 wheels.	Correct air pressure.
65 mm.	650— 900 lbs.	50 lbs.
	900—1200 ,,	65 ,,
	650— 900 ,,	40 ,,
85 ,,	900—1100 ,,	60 ,,
	1100—1300 ,,	75 ,,
90 ,,	900—1300 ,,	75 ,,
100 ,,	1300—1750 ,,	90 ,,
105 ,,	1750—2000 ,,	95 ,,
120 ,,	1300—1750 ,,	75 ,,
125 ,,	1750—2200 ,,	90 ,,
	2200—2600 ,,	105 ,,
135 ,,	1750—2200 ,,	105 ,,
150 ,,	2200—2700 ,,	110 ,,
	over 2700 ,,	120 ,,

Non-skid covers require a pressure of 15 lbs. more than that given in this table. As pressures are not standardized to suit each and every make of tyre the makers' lists should be consulted as to the pressures they specifically recommend.

Detaching and Repairing Tyres

The following instructions are those specially compiled for the manipulation of the Dunlop tyre, but practically the same rules apply to any standard tyre. The deflation of a tyre through puncture is indicated by the wheel bumping on the road, or the steering becoming unsteady. This necessitates an immediate repair of the punctured air tube, or, what is more convenient, the replacement of the damaged tube by a sound one. To remove the air tube, first jack up the wheel, then loosen the security bolts as far as the wing nuts will go without removal. The external parts of the valve are next removed (care being taken to place any of the loose fittings in a safe place). The cover detaching or tyre levers are next requisitioned. The edge of the cover

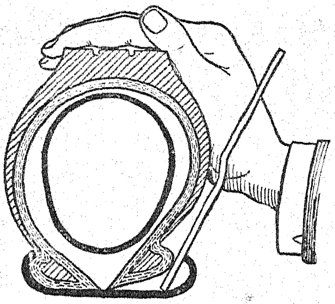
can then be pushed from under the lip of the rim, the levers inserted in positions several inches on each side of a rim bolt and the edge of the cover raised over the rim, special care being taken not to damage the air tube. Should the cover slip back, the levers must be set a little farther apart; but, if placed too far apart, the cover will not come over the rim, so that they must be used closer together. The levering must be repeated at intervals of about six inches until all the edge of the cover is brought over the rim, care being taken not to insert a lever where it will touch a rim bolt. Should the air tube be difficult to remove through sticking to the cover, it may be necessary to apply some petrol to the place. The cover must, however, be allowed to dry thoroughly, and French chalk rubbed on afterwards. The inside of the cover should then be carefully felt for puncturing objects, such as bits of wire, flint, or nails sticking inside, and same removed. The cover should also be cleaned thoroughly of any loose gritty material that may be inside. Afterwards a handful of clean French chalk should be put in and shaken round. When inserting the new tube



Left—Chain pattern detachable non-skid; can be used on either plain or grooved treads; can be easily attached when required. It forms an effective grip for driving through snow. Centre—Special form of flat moulded tread with recesses and side ribs. An efficient type of non-skid cover gripping the road by the suction effect of the circular recesses. Right—Combination tread; rubber and steel studs and rubber ribs.

see that it is first of all slightly inflated, and make certain that it is put in quite straight and free from any twists or kinks, which would be certain to cause trouble later on. The tube in position, first replace that part of the cover which is notched to fit round the valve, go round to see the air tube is straight once more, and then push up the valve and security bolts, in order to allow the edges of cover to fit into the lip of rim. Next draw the valve and bolts down into position. The greatest care should be taken in using the tyre levers not to pinch or injure the air tube. If the operator has to work single-handed difficulty may be experienced in detaching the cover. The best method in this case is to use three levers. Two levers are inserted, and the wheel turned round so that one lever rests against the foot and the next against the leg of the operator. Both hands are then free to manipulate a third lever. The same method applies in replacing the cover. To remove the valve insert the curled end of the lever over the tube, then push it across till it catches hold of the tyre on the opposite side of the rim. The cover can then be pushed up out of the way with one hand, and the valve withdrawn with the other. To completely detach a cover, insert the lever on inner side of wheel, two inches away from a bolt. Lever up the bead of the cover from the

rim, and then pull the bolt down, so that the bolt head will be underneath bead of cover. Repeat operation at each bolt. Next insert a lever from inner side of wheel right across the rim and lever the tyre bodily off. The rim bolts should be fitted in slots, so that they cannot turn round. If the holes are round care must be taken to manipulate the head of bolts into correct position. In the event of a repair having to be made to an air tube, the process is the same as for an ordinary

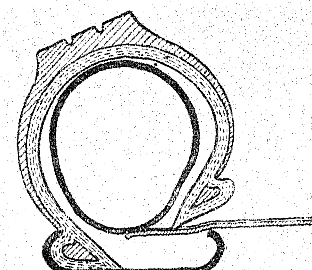


The first operation in removing a tyre cover: After the security bolt wing nuts have been slacked off, the edge of cover is pushed out of the rim and the tyre levers inserted. Various forms of levers are obtainable, some being more convenient to use than others. The various tyre makers supply suitable levers for their tyres.

cycle tyre tube, but special bevelled patches and strong solution must be used.

In the event of a burst in the cover a special canvas patch should be fixed right across from edge to edge, so as to be gripped under the beading. Another device is a corset, which attaches round the air tube at the weakened part of the cover. Reinforced tubes may be used as a protection against bursts. These tubes are made with a fabric insertion around the greater part of the circumference. A tyre

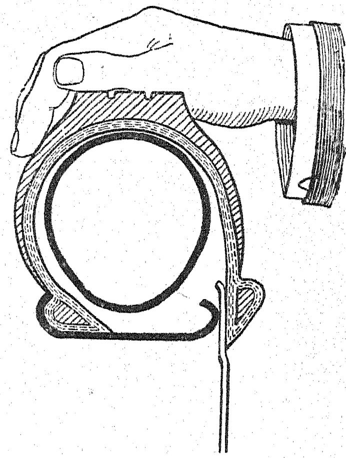
Second operation: The lever raising the cover over the edge of the rim. Special care must be taken not to pinch the air tube between rim and lever. This would result in damage to the tube, rendering it useless till repaired. Even if not cut through, the rubber would be so much weakened as to burst under the effect of air pressure on some future occasion.



gaiter is a useful article for strengthening a weak place in the cover and getting home after a repair. When such is fitted, it is advisable to drive at a moderate pace only. From time to time the outer cover should be closely inspected, and any appreciable cuts found therein should be well cleaned with petrol or benzine, and filled up with some of the special plastic rubber preparation sold at accessory or tyre depots.

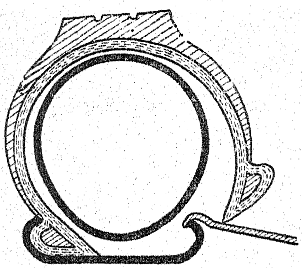
The durability of a tyre depends primarily upon the quality and treatment (such as vulcanization) of the rubber used in its construction, but there are a number of other factors which have an important bearing upon it which the user can largely control. For example, correct inflation for the weight the tyre has to support (inflation tables are given on another page). The use of a tyre of large-enough section is another important factor. The tendency amongst many car owners

is to use tyres of minimum size for the work. This does not prove in the long run the most economical course to adopt, because it has been abundantly shown that the life of a tyre increases very greatly with

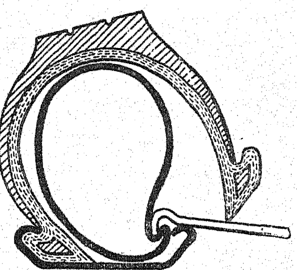


Third operation: The hand is used in assisting the working of cover down outside the rim, the lever being in position between cover and rim. A new cover will generally be found stiff to manipulate with the hands for the first time, but soon becomes supple with use.

an increase in size. Many cars are now fitted with extra large diameter tyres with a very notable increase in durability and also comfort in driving, because the greater the air space the greater the cushioning effect. The increasing cost of tyres larger than the minimum which



Fourth operation: The inner tube having been carefully replaced, the hooked end of the lever is used to work the edge of the cover back into the rim.

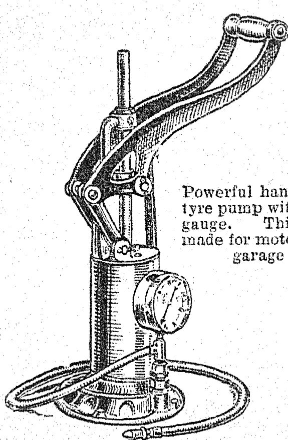


How an air tube may be injured by an inexperienced or careless operator in replacing a cover. The tube is shown nipped between the end of a hooked lever and the lip of the rim.

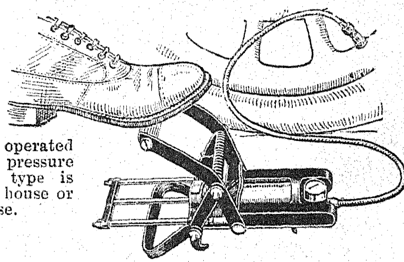
can be used, it will be found, is amply justified by results. Another factor contributing to durability is the "nursing" of the tyres on rough or stony roads by driving slowly when there is much risk of the treads being cut. Care in starting and stopping the car is another important factor, skidding or locking of the wheels by a harsh clutch or brake being most destructive. Carefully-used tyres will be found to give a large mileage, and it is possible, in most cases, to have them retreaded by the makers and another long period of life obtained from them.

Tyre Inflation: Various Types of Air Pumps

For tyre inflation a first-rate pump is a necessity. The most commonly-used is a single barrel, single-acting hand pump; but for rapid inflation, with a minimum of exertion, double or triple barrel pumps may be used with advantage, as these act both on the up and down stroke. A foot-actuated type of pump can now be obtained which greatly simplifies tyre inflation. Mechanical pumps for working direct off the engine can also be obtained. The pump, which may have a single or several barrels, is usually mounted on a swing bracket, and has a friction wheel to come in contact with the engine flywheel when required. One form is made to be held against the flywheel by hand. The connection to the tyre valve is made by a flexible tube. Another alternative is to use one of the cylinders of the engine as a compressor.



Powerful hand operated tyre pump with pressure gauge. This type is made for motor house or garage use.



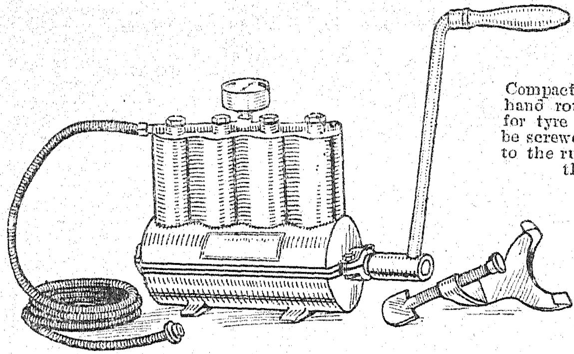
Foot pump for easily inflating a tyre. The pump can be folded up for easy storage.

A special form of sparking plug containing a valve is used, with a tap and union for the tube connecting up to the tyre. The air is forced into the tyre on the compression stroke, the spark, of course, being cut off so that this cylinder does not fire. A method of rapid inflating which saves all trouble is to use a small steel cylinder or "bottle" of liquefied carbon dioxide gas. This is supplied with a special fitting for connecting up, and a pressure gauge for indicating when the necessary degree of tyre pressure has been obtained. A small double-compression pump, which can be screwed into the sparking plug aperture of one of the cylinders and thus worked automatically, is much used. Air is drawn into the cylinder through a valve in the pump and forced into the pump, which, by a further compression, forces it into the tyre. Cars having compressed air starting-up devices are always equipped for rapid tyre inflation from the air pressure cylinder. A compact four-cylinder pump driven by gearing from the engine is now much used.

Tyre and Valve Hints

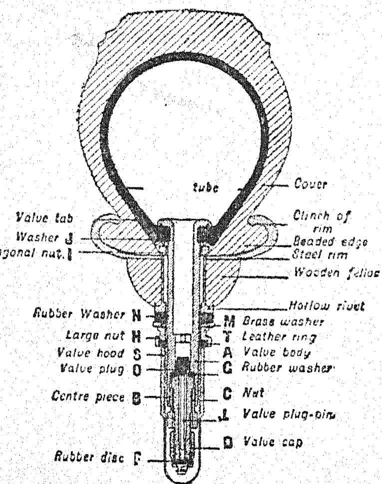
It is essential to the avoidance of trouble through slow leakages in tyres to invariably keep the dust caps on and well screwed down, otherwise dust gets in, and is sure to find its way to the rubber seating when next the tyre is pumped up. Should, therefore, a cap be lost on the road, and a spare one is not at hand, blow away as

much of the dust as possible and tie a piece of rag or cloth over the valve. For the same reason it is a good plan to make a habit of giving the pump a few strokes before connecting it up, to expel any dust which has found its way into the tube. Tyres should always be kept hard or to the pressure indicated in the respective makers' lists, they being less liable to puncture than when soft, and there is less tendency to creeping or rolling in the rims, not to mention the ingress

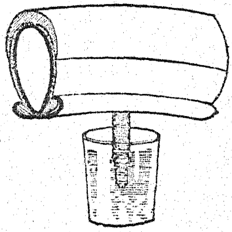


Compact four-cylinder hand rotary air pump for tyre inflation. Can be screwed or clamped to the running board of the car.

of wet being prevented. A rough indication of correct inflation is to shake or rock the car sideways, when the tyre should move *with* the wheel. If the part of the tyre on the ground does not move sideways solid with the wheel, more air should be pumped in. At the same time, it should be remembered that the heat of the sun in the summer time tends to keep the tyres much hotter in running than is the case in winter, so that a little allowance for expansion may be made. If it so



Section of tyre valve, showing parts.

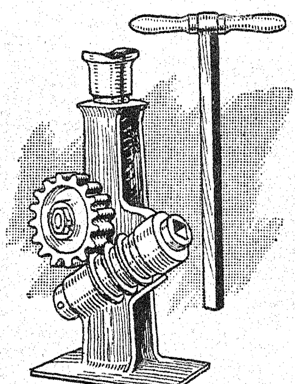


Simple test for air leakage at a valve by immersing in water and observing if any bubbles escape. Any leakage will probably be due to the small rubber valve plug (**O**) having become defective.

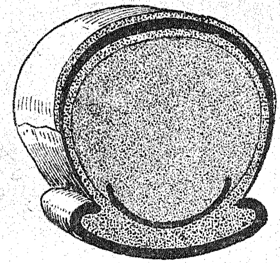
happens that any particular tyre runs for a lengthened period during the hot weather without requiring inflation, it will, in all probability, be found, on eventually attempting to free the valve preparatory to pumping up (the small pin on the cap of the Michelin and Continental valves is provided for this purpose), that the soft bit of rubber inside has been melted by the heat and stuck up, and a spare one will then probably have to be inserted before the valve will hold properly.

Resilient Materials as Air Substitutes

In addition to such devices as detachable rims, removable flanges, and special means of getting at the air-tube quickly, an alternative method is to discard compressed air as the vibration-absorbing medium, and use a substitute, a solid material, having a high degree of elasticity and being relatively light in weight. The air-tube is filled up by a special process with some preparation of this kind, and the cover used in the ordinary way. A tyre of this class is more resilient than a solid rubber tyre, lighter, and less costly. The weight, however, is considerably greater than a pneumatic, and the resiliency less, thus having some adverse effect on speed. So far as comfort and vibration absorbing properties are concerned, the difference between it and a fully-inflated pneumatic is not very marked, and an ordinary observer would have difficulty in telling whether he was riding on air or on an air-substitute tyre. The several resilient filling preparations for tyres are the subject of patents, and special trade processes are involved, and therefore details cannot be given here, but it may be said that materials such as cellulose and spongy rubber form the basis of some of them.



A standard type of lifting jack.



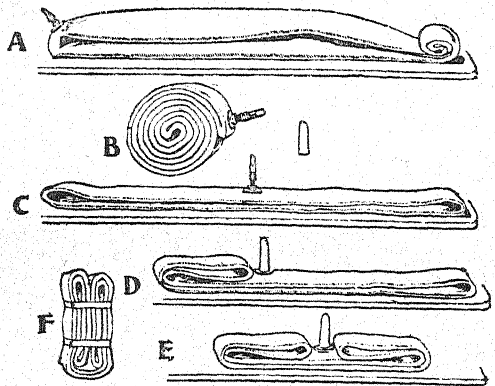
Section of tyre filled with an air substitute of resilient material.

Air Pressure Gauges

These devices are very useful for ensuring that the tyres are always kept up to the correct degree of working pressure. The gauge can be screwed on to the valve direct, when the pressure is at once read off on the dial. If desired, the gauge can be obtained as a fixture to the tyre-inflating pump, and the pressure read off whilst pumping.

Car-lifting Jacks

In connection with tyre repairs, an efficient jack or lifting appliance is indispensable. These jacks are made in numerous patterns, and all embody some arrangement of the screw and lever. When placed under the axle and adjusted the jack forces up the axle, so that the wheel is raised clear of the ground, and the tyre can therefore be manipulated without difficulty. Some care is necessary in adjusting a jack, so that when the weight of the car is supported by it there is no risk of the jack slipping and letting the car down suddenly. The strength and design of the jack should also be properly considered when choosing it. The strains on the parts when in action are very great, and if the jack be not made of high quality material (steel) and well proportioned to resist wear of the screws and ratchets it will inevitably give way when under load. Ball bearings are used in many of the more modern types of jack to take the thrust and render their operation an easier matter. Pneumatic jacks are used to some extent, but are chiefly applicable to cars which have an air compressor for starting up the engine. These simply require connecting up to the compressed air reservoir.

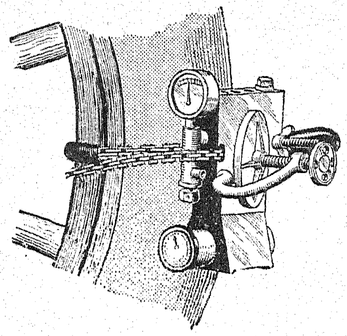


Showing the various operations in folding an air tube properly

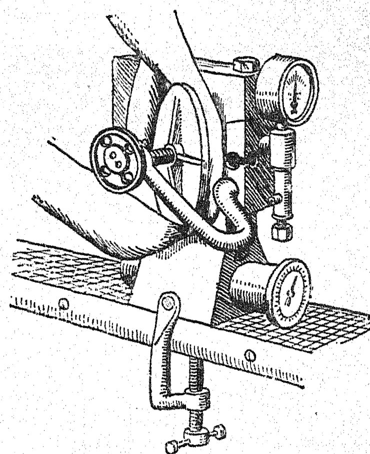
Care and Storage of Air Tubes

It is important that air tubes should be carefully kept, and note should be taken of the correct method of folding them as follows :— The tube must first be denuded of its air, and for this purpose it is folded, as in A, so that the valve body (from which the cap and the valve parts have been removed) is at one end. Then starting from the other end, the tube is tightly rolled up, the air being assisted to escape by the prevention of air locks through the folding of the rubber near the valve body. When the tube is completely rolled, as in B, with all the air out of it, the valve is made up and the cap screwed on. The tube can now be opened out flat, and, provided there is no puncture or any means of air ingress, it will stay flat. It is now best to bind round the valve with some cloth, or, better still, a thick rubber finger stall to prevent chafing of the tube The tube is laid out, as in C, so that

the valve is central, and then one half of one end of the tube is folded over towards the valve (D), the other side being similarly folded, the ends of the folds nearly touching the valve (E). The two parts of the tube are now brought together and bound with a broad tape, or clamped by a couple of rubber bands (F). It will be seen that, by this method, the valve can never be rocked over at such an angle as to strain the valve seating; in fact, it is completely prevented from moving, and every fold is a natural one. The tube should now be placed in a waterproof inner tube bag with some French chalk, and it can come to no harm. When a tube is punctured, it will be found impossible to fold it in this way because of the ingress of air, and then the only way is to stop when the tube is as in B, and be careful that it is placed in such a position that the valve cannot strain the seating.



Portable tyre vulcanizer for cover and tube repairs. Steam heater process. The vulcanizer is shown clamped directly on to a tyre whilst on the wheel for repairing a damaged place on the tread. Methylated spirit is used in the burner.



The same vulcanizer in use repairing an air tube. For this purpose it can be clamped to the footboard of a car

Non-Bursting Air Tubes: Use of Liners

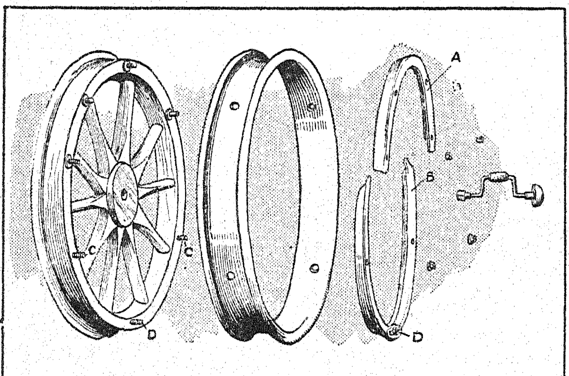
In the event of a cover weakening at any place, the ordinary tube will usually blow through and burst; this is known as a "blow out." By using a tube specially made, having a fabric insertion, a blow out cannot occur. This form is known as a non-bursting tube. Another device, known as a "corset," which is a special shaped lining having an

opening for inserting the tube, may be used with a cover that is weak. This may be used in sections or as a complete liner to the cover. Weakened covers should preferably be used on the front wheels with reduced air pressure.

Vulcanizing Repairs in Tyres

Simple and effective vulcanizers are sold suitable for tyre repairs, and repairs so made to air tubes and covers are much more permanent than solutioned repairs. Full details how to use such apparatus can always be readily obtained from the makers or factors of them. These vulcanizers are made in very portable form, and such as can readily be carried on a car, and a repair effected whilst on the road.

One much-used pattern vulcanizer consists of a steam heater with a spirit burner fitted underneath. It is specially shaped so as to offer a concave surface for clamping direct to a cover, which may have to be repaired at one or more places. The defective part of the tyre is first of all prepared by cutting and cleaning in a particular way, then it is filled up with a kind of plastic rubber, and the vulcanizer is clamped over it and heated for a certain length of time. The result is that the repair is made homogeneous with the rest of the cover; in a sense, it is welded to it permanently. Repairs to air tubes are made by



A type of detachable rim. The tyre rim is held on the wheel felloe by the split wedge-shaped flange (A D). The turning of the fixed nut (D) levers the flange out of its seating. The brace is used for quick removal of the nuts from the bolts (C D).

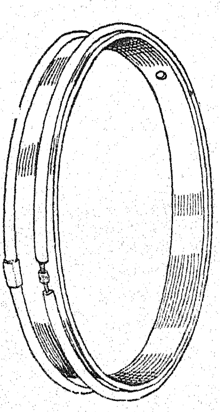
clamping to the flat sides of the vulcanizer. Other forms of vulcanizers have the metal surface heated by hot air, and some means of shutting off the heat automatically when the correct temperature is reached. There is also the electrical type. This consists of a "heater," generally made of aluminium. Inside is arranged a "resistance" coil protected with mica. A current from an accumulator of four or eight volts is passed through the coil, and heat is evolved and concentrated on the surface of the vulcanizer. The special advantages of this device are its safety in use and portability and convenience, and the fact that exactly the right degree of steady vulcanizing heat is obtained by the passage of the current. It is better to use cells of special size rather than ignition cells, owing to the rate of discharge being fairly high,

Retreading Covers

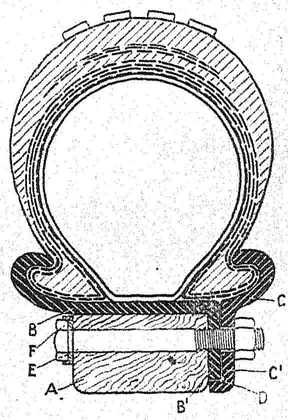
By having covers retreaded by the tyre makers before they are worn out, a considerable extra mileage can be obtained. In some cases it amounts to about two-thirds the average mileage of a new cover, but in most cases at least half the normal mileage can be obtained, and thus a considerable saving in cost of new tyres is effected. A tyre that has been properly looked after by having the cuts vulcanized as soon as they develop will be capable of more satisfactory retreading than otherwise, as in this condition the fabric lining would be little the worse for wear. A weakened cover, although it may be capable of being retreaded should preferably be used on a front wheel and not subjected to driving strains.

Special Tyres. Detachable Rims and Wheels

To considerably lessen the delay caused by tyre troubles when on the road, wheels fitted with detachable rims may be used. The principle underlying the system is to have the wheel made with a plane and accurate felloe, on to which the tyre rim, with a fully-inflated tyre "in situ," can be fitted. It is, therefore, only necessary



Special rim with expanding ring on one side to quickly detach a tyre of the wired edge type.

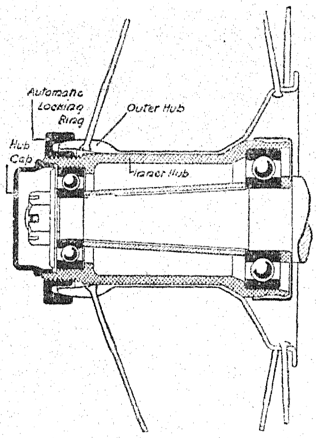


Section of a detachable flanged rim. A, felloe BB^1, fixed portion of the rim shrunk on to felloe CC^1, detachable flange; D, small channel in C containing strip of packing; E, fixed steel bolt secured by the locking plate (F). The flanges $(B^1, C^1,)$ form a close joint.

in the event of a puncture to unfasten several screws or similar fitments round the rim, and take off the damaged tyre and rim. The new rim is then slipped into position, the attachment made secure. and the car is ready again. One or more spare rims and tyres can be carried. Although tyre repairing is a very much simpler matter now than in the early days of motorcar development, there are times and conditions, such as in the case of unfavourable weather, when the advantages of the detachable rim would be very marked. An alternative attachment, very useful in the event of damage to a tyre occurring, is a spare rim or "Stepney" wheel, which has fittings, etc., to grip

the rim and spokes of the wheel of which it forms an extension. It is thus fixed alongside firmly and concentrically, and the running strain taken entirely away from the damaged tyre.

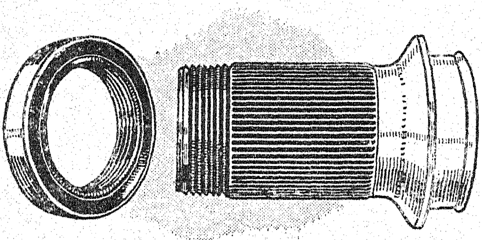
Detachable rims are now made which have the extra advantage of allowing the tyre to be easily taken off. The rim is divisible in two or more parts, and the circumference can be made less than that of the tyre when it has to be taken off.



Section of Rudge-Whitworth detachable wheel hub, as used for a front wheel.

Rudge-Whitworth Wheel

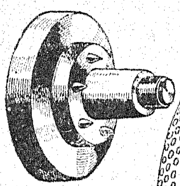
As a leading example of the detachable wire wheel the Rudge-Whitworth type may be described. Apart from the ease of detachment for replacing one with a fully inflated tyre, which this wheel provides, there is a considerable saving of weight. As experience has conclusively shown, it is an advantage to reduce the weight in the rim

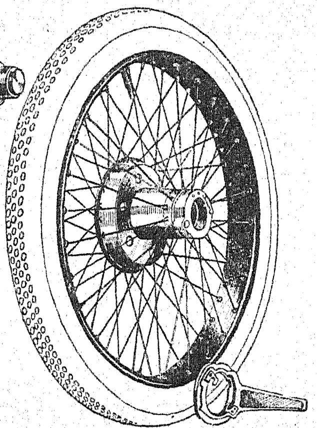


General view of Rudge–Whitworth inner hub and the simple automatic locking ring.

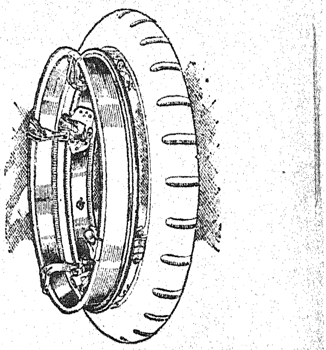
as this is favourable to the durability of the tyre. These wheels have great lateral strength, and in the event of a sideways collision with a kerb or other obstacle there is no danger of collapse. The wheel may buckle, but it cannot break. The principle of this type of wheel is a very simple one. The fixed hub on the axle is provided with parallel serrations or teeth of fairly fine pitch, and the wheel hub shell is

provided with groves which engage with the fixed hub serrations very accurately so that a solid driving fit is obtained. To ensure that when the wheel is in position on the hub there shall be no risk of it coming off unintentionally, a most important requirement, it is provided with an automatic locking device. In the Rudge-Whitworth wheel it is of a particularly simple and efficient type, as it is merely a grooved ring which engages with the thread on the inner hub and with the tapered face of the outer circumference of the wheel hub. This simple construction provides an automatic wedging action which keeps the wheel firmly in position on the hub. Even if left loose at the start of a run the lock ring will tighten itself on the hub in a very short distance, so that the tendency is always for the wheel to be securely held





Riley detachable wire wheel system, consisting of an inner hub, fixed to shaft and provided with tapered driving studs, which engage with holes in the wheel hub. The inner hub and wheel hub shell are made a taper fit and this practically takes the drive.



Stepney emergency rim with inflated tyre attached to rim of damaged tyre by the four clamps. It is unnecessary to remove the damaged tyre as shown.

Guide to Limit of Power of a Car for Given Sizes of Tyres (Minimum)

8 to 16 h.p.—90 mm., or 90 mm. front, 105 mm. back for heavy bodies; extra heavy bodies—105 mm. front, 120 mm. back.

16 to 22 h.p.—105 mm.; heavy bodies—105 mm. on front, 120 mm. on back.

24 to 35 h.p.—120 mm. front, 135 mm. back.

35 to 75 h.p.—135 mm. both.

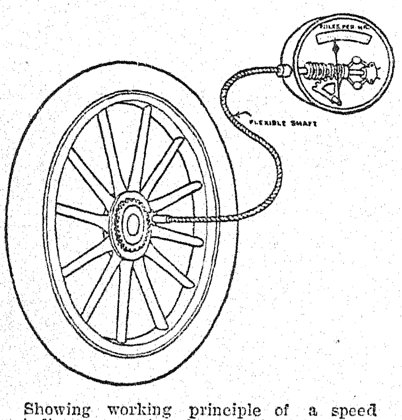
Larger cars and racing vehicles are now fitted with 150 mm. or 6 in. and 175 mm. or 7 in. tyres. The use of extra large diameter tyres is also recommended on smaller cars when the question of initial cost has not to be seriously considered. For very heavy vehicles twin wheels are sometimes used. This means that the load is distributed over four back tyres instead of two. The wear on each tyre is found to be greatly reduced, that is to say, that the life of a set of twin tyres is much greater than two pairs of tyres used singly.

CHAPTER IX

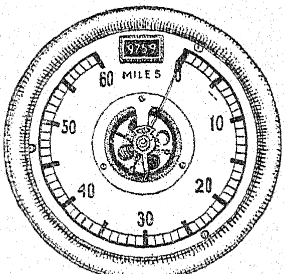
Accessories and Special Fittings

Speed Indicators and Distance Recorders

One of the most useful of permanently-fitted car accessories is a speed indicator. As the result of the large amount of attention which has been given to the design and manufacture of these instruments, the motorist now has a very large range of accurate and reliable indicators to choose from. Instruments are sold from about £3 upwards, and special models for indicating high rates of speed on racing tracks, reading up to 140 miles an hour, are made. Speed indicators are fitted permanently on the dashboard, and well in view of the driver, and are operated by a variety of methods direct from the road wheels. In the construction of these instruments much ingenuity has been shown. A number of principles are adopted, that most favoured being centrifugal force. An ordinary "flybob" governor, rotated from the road wheel by a flexible shaft, actuates, by means of magnifying gearing, a needle or pointer moving across a scale graded in miles per hour. The mechanical details of these instruments vary greatly, the governor being made in various forms and not always on the flybob system, although the principle is the same.



Showing working principle of a speed indicator (centrifugal type). Positive drive by means of gearing.

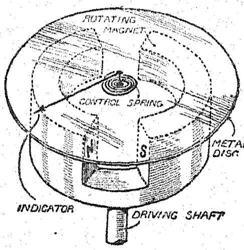


Dial of magnetic speedometer with mileage recorder.

There are several electrical or electro-magnetic speed indicators. In one system a small magneto-dynamo (driven by a belt from a pulley rim bolted to the inside of one of the steering wheels) generates an alternating current, which is carried by a flexible conductor to a voltmeter, which really indicates volts proportional to the speed, but the gradations are shown in "miles per hour," instead of volts. In one system the indicator needle is controlled by the expansion and contraction of a very fine wire through which the current passes. There are also indicators which embody electro-magnetic action, such as

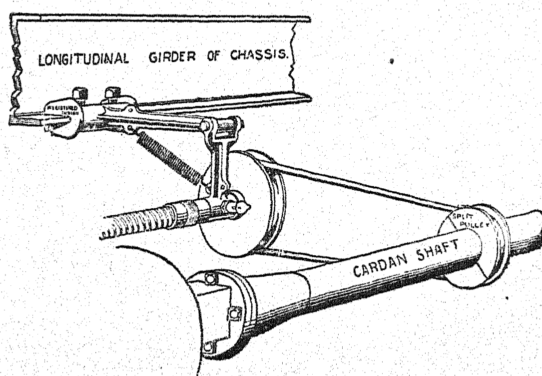
the rotating of an aluminium disc or cup at a fast rate between the poles of a permanent magnet. The currents generated in the disc or cup result in it being pulled partly round on its axis against the tension of a spring, and thus actuates the needle of the indicator. One obvious advantage of the electro-magnetic principle is its simplicity, the number of mechanical and working parts being reduced to a minimum. On the other hand, it is contended that the accuracy cannot be so permanent as is the case with the mechanical type of instrument, as variations in temperature and the weakening effect of age and vibration on the permanent magnet have to be taken into account. Nevertheless, these instruments have proved to possess great reliability in practice.

In certain types a second needle is provided, moving across the scale, but always remaining permanently at the highest figure reached. This forms a "maximum" indicator, which can be released at will by pressure on a button. Various forms of drive are employed, the



Illustrating principle of magnetic speedometer. A "torque" or pull is created in the metallic disc by the rotating magnet beneath it. The angular movement of the disc increases with the speed of the magnet.

"positive" system being considered the most reliable. In this a toothed ring is bolted to a front wheel, and engages with a small pinion, which rotates the flexible shaft connecting up with the indicator. Another form is that of a friction disc and wheel similarly arranged, and there is more "flexibility" in this arrangement; but, on the other hand, slipping between the disc and wheel may possibly occur and affect the accuracy of the readings. There is also the belt arrangement previously referred to. Distance recorders, odometers, or mileage indicators are embodied in nearly all the well-known makes

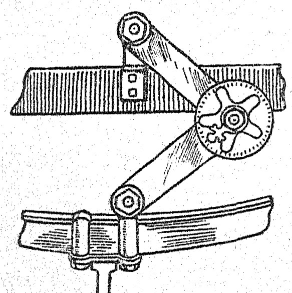


Improved method of driving a speedometer flexible shaft in which the disadvantages of driving direct from a front wheel are obviated. The belt is self tensioning by the spring-controlled bracket.

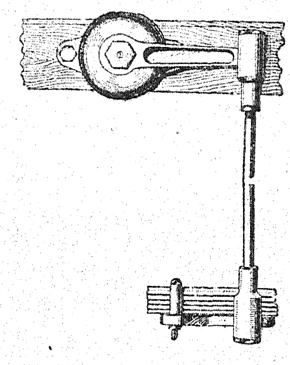
of speed indicators, but are also obtainable as separate instruments. The principle is mechanically well known as that of the "counter" mechanism, in which trains of small gearwheels of various ratios control the numbers. A "trip" recorder indicates the distance of each run separately, and can be re-set to "zero" at will, whereas the main recorder runs from zero to 10,000 miles or more. One convenient form of mileage recorder screws direct to one of the steering wheel hubs.

Shock Absorbers

These devices, of which there are a great number on the market, are made for the purpose of improving the comfortable running of the car, more especially on roughly-surfaced roads. The present system of springing is admittedly not perfect, and when travelling on rough roads there is the objectionable rebound of the body of the car after it passes over a depression in the road, which it is desirable should be reduced as much as possible. The shock from this rebound is not only uncomfortable for the passengers, but it has a bad effect in several ways on the whole car. Hence these shock absorbers are applied as the best means available so far to check the rebound. They are made on various principles, generally employing a frictional effect such as is



Friction disc shock absorber. Case-hardened steel discs fastened to the hinged arms are kept in close frictional contact with each other, and act as a "brake" on the rebound.



Hydraulic shock absorber (Houdaille).

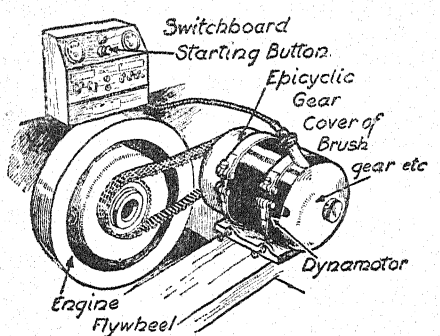
obtainable from two hardened steel surfaces in close contact. Another principle is that of using the fluid friction of oil, practically on the lines of any of the well-known "dash pot" devices, viz., a piston moving in a cylinder against the resistance offered by oil contained within it, the oil passing slowly through a small aperture into another chamber. This type of device is probably the best solution of the problem.

Auxiliary Springs

These appliances are quite different to the shock absorber, though they are often used in conjunction with them. The main idea in applying them is to provide a greater range to the ordinary elliptical springs so that the minor and more numerous road vibrations will be absorbed, leaving the main springs to absorb the more severe vibrations. The wide application of these numerous appliances proves that they are effective to a considerable extent. In practically every type they consist of spiral springs working in cases and attached to the shackles of the main springs.

Engine Starters

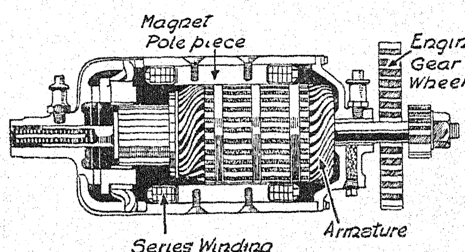
Important advances have been made in the overcoming of the inherent drawback of the internal-combustion engine, namely, its inability to start automatically. A great many cars now have some form of starter fitted, but it will probably take a long time to eliminate the starting handle as a standard feature of car construction. The advantages of a starter are so obvious that they do not need recapitulation. The solution of the problem has been considerably aided by the application of electricity to the lighting of the car, and as a result the electric type of starter is the more largely adopted. In addition to this system there are several which act by compressed air and others by springs. The principle of the electric type of starter consists in the use of a series-



T.A.T. dynamotor type of starter with chain drive to engine.

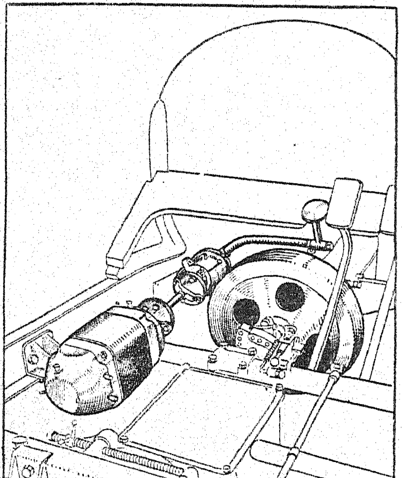
wound electric motor, deriving its energy from an accumulator battery, which can also serve the purpose of lighting the car. The starting motor can also be designed to act as a charging dynamo, in which case it is known as a "dynamotor" or combined motor and generator. The

Section of Rushmore electric starter. The armature pinion automatically engages with the engine gear when current is switched on, and releases when current is switched off.



electric motor has to develop for a very short time an amount of power which may range from $\frac{1}{2}$ to 1 b.h.p., according to the size of the engine to be started. The electric type of motor is peculiarly well adapted for the work, as its characteristic feature is that of being able to produce a very powerful and continuous torque, which enables it to overcome the inertia of a stiff engine and its high compression. There are various methods of applying the power from the electric motor to the engine, the simplest being that of friction drive. This consists

of a small and wide roller made of rubber and fibre discs keyed to a flexible extension of the motor shaft and connected by levers up to a pedal, so that, on pressing it, the current from the accumulators is switched on to the motor, and further pressure brings the revolving roller into firm contact with the wide face of the engine flywheel. With a small-diameter roller driving on to a very much greater diameter wheel ample leverage is obtained to rotate the engine. The other methods of transmission are by gearing, consisting either of a pinion on the motor shaft engaging a toothed ring on the flywheel or a plain drive by a chain, a sprocket being keyed to the motor shaft and another to any convenient part of the engine crankshaft, the two being connected by a driving chain. Some of the electric starters are provided with an epicyclic gear to reduce the transmission speed. This system is



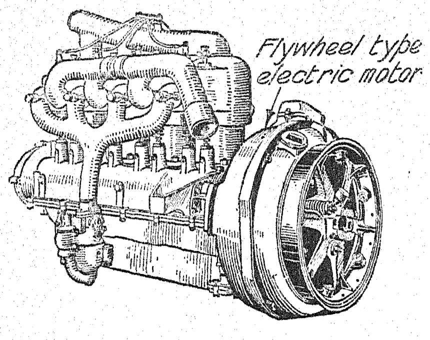
C.A.V. electric engine starter with friction drive to engine flywheel. Current is switched on and friction roller engaged by pressure on the small pedal just above the flywheel.

more general on the dynamotor or single-unit type of machine, as it is in most types necessary to have two gear ratios—a very low one about 20 to 1 for starting and a high or direct gear of about 3 to 1 for driving as a lighting dynamo. A single-geared machine is, however, quite practicable, as there are examples of this type in successful use. The gear ratio ranges from 3 to 1 to 4 to 1, according to the size of the engine, and although this necessarily means that the armature of the dynamo may at times run at very high speeds, viz., between 4000 and 5000 r.p.m., there are no adverse effects, proving that the armature windings are protected against the severe centrifugal stresses that occur. Another type of electric starter is that designed to take the place of the engine flywheel. This has the advantage of applying its power directly to the crankshaft. It is also simple and avoids the use of separate machines.

Spring Starters

The energy that can be stored up in a spring is utilized in some forms of automatic starters. The general arrangement is to use a flat coil spring of considerable strength, and combine it with a simple clutch mechanism. The spring is enclosed in a metal case and placed

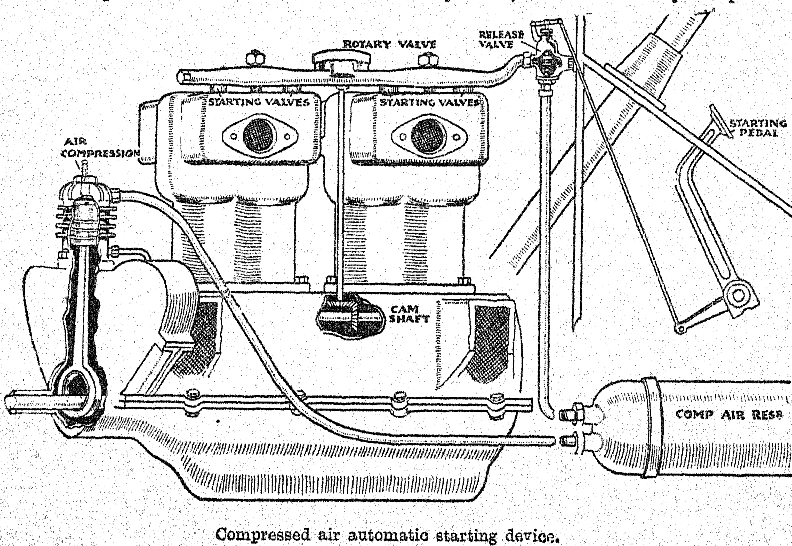
at the forward end of the engine shaft in place of the starting handle. The working is briefly as follows:—The engine winds the spring up automatically through the clutch, and it can be put into engagement with the crankshaft by a suitable control lever, convenient to the driver, and it then gives a number of rapid revolutions of the shaft sufficient to start, the engine, and as the apparatus is always kept in a fully wound up state the starting up can always be readily effected. Another arrangement of the spring embodies it in the gearbox.



Electric starter in which the motor is designed as part of the engine flywheel, thus providing a direct application of power to crank-shaft.

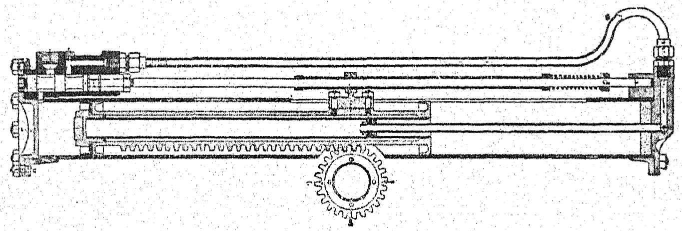
Compressed-air Starters

There are, broadly speaking, three types of these. The chief is that in which air at a pressure of about 250 lb. per sq in. is admitted direct into one or other of the engine cylinders by means of a special distributing valve. The pressure acts directly on the piston and operates on the cylinders in correct sequence, thus giving a series of impulses. The compressed air is stored in a steel cylinder, which is always kept



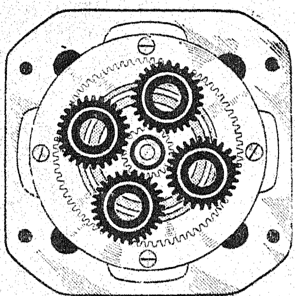
Compressed air automatic starting device.

charged up from an air compressor driven by the engine. The second system is simpler and consists of a long cylinder containing a piston, to which is attached a long rack, which gears with a pinion wheel fitted to the forward end of the crankshaft. The pinion is provided with



Rack and pinion type of compressed-air starter. The pinion is attached to engine shaft with a free wheel clutch. The admission of compressed air to the cylinder which carries the rack forces it outwards and thus causes rotation of the pinion.

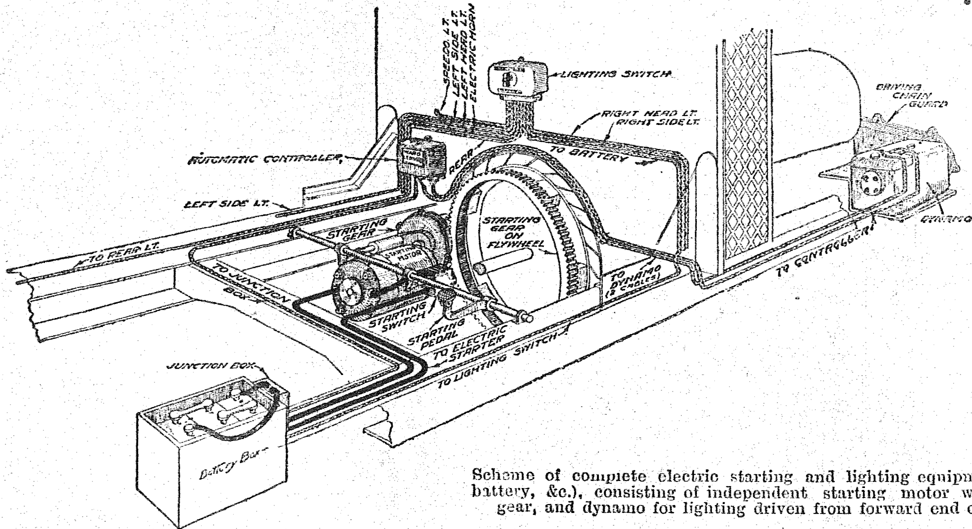
a free-wheel clutch, so that the engine, so soon as it starts, can run free of the starter. The operation of the starter is simply that of admitting compressed air into the cylinder, the piston being at the commencement of its stroke. The pressure drives it forward, and the rack and pinion thereby rotate the engine shaft. The piston is returned to its starting position by means of a spring, so that several strokes can be obtained. The other pneumatic system comprises a separate motor, usually of four or six cylinders. Its shaft is provided with a small pinion, which can be brought into gear with a toothed ring on the fly-wheel rim. Compressed air is admitted from a steel cylinder as in the other systems.



Epicyclic gear for speed reduction. Arrangement as adapted to electric starter of dynamotor type.

Pedal and Lever Starters

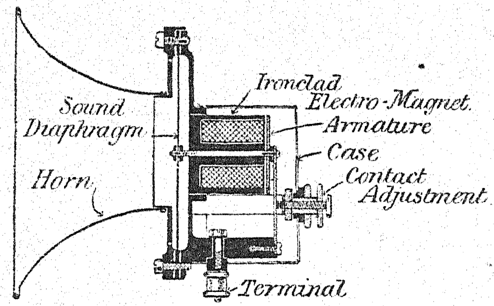
These are devices which simply transfer the starting handle operation to a more convenient place near the driving seat. In one system a ratchet is fixed on the clutch shaft, and this can be engaged by a pawl on depressing a pedal so that the engine shaft is rotated. The same action can be obtained by pulling a hand lever forward in the manner of a brake or gear lever, its connection being made by a wire cable.



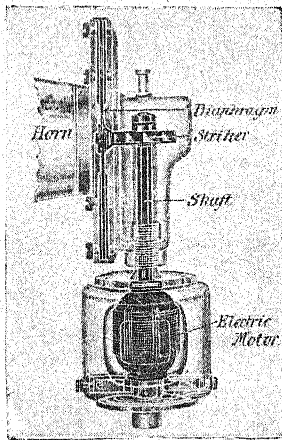
Scheme of complete electric starting and lighting equipment (wiring, battery, &c.), consisting of independent starting motor with flywheel gear, and dynamo for lighting driven from forward end of engine.

Road Warning Devices

Every motorcar must carry some means of giving audible warning of its approach. The standard instrument used for this purpose since the early days of the motorcar is the ordinary reed horn operated by the pressing of a rubber bulb which forces air through the horn. The reed horn is still largely used, but in much improved forms, giving a large volume of sound of great carrying power, but two chief alternative systems have within recent times come into vogue in which electricity



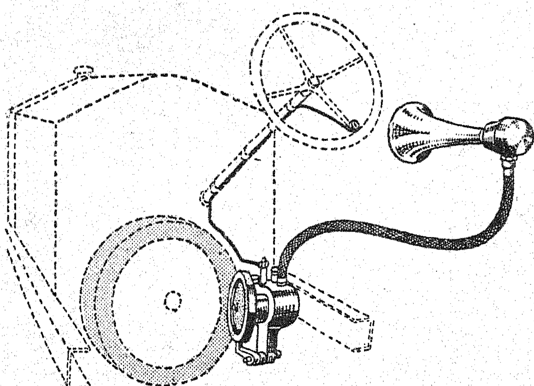
A



Two examples of electric warning devices.

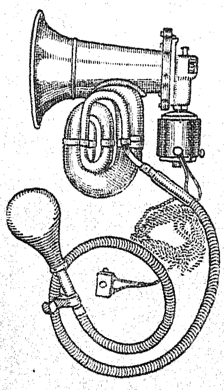
B

and the energy of the exhaust gases are used respectively to produce a warning sound. Electric horns are of two types, the chief one being based on the principle of construction shown in the illustration above (A). An electro-magnet is energized by a current from either an

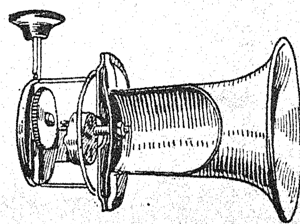


Mechanically operated horn, air pressure is supplied by a rotary pump, which can be brought into engagement with the flywheel at will.

accumulator or a dry battery by pressing a button. The magnet attracts an armature disc of soft iron, which is supported by a spring. This armature vibrates very rapidly by means of an ordinary contact make and break, as used in an electric bell. The armature is centrally connected by a rod to a thin sheet iron diaphragm arranged at the base of a horn or amplifier, and by its extremely rapid movement sets in vibration the air and produces a powerful note. Another electrical type of horn has the electro-magnet replaced by a small high-speed electric motor (B). The end of the motor shaft carries a small cog or striker, which hits the centre of a thin metal diaphragm and thus sets it into rapid vibration. Instead of a diaphragm being employed, the motor may rotate a perforated metal drum and thus produce sound on the principle of the syren. Exhaust whistles and horns are used to a considerable extent, the principle most favoured being that of an organ pipe. The reed principle can be used, but is not considered so reliable. The usual arrangement is to connect the horn or whistle at the side or rear of the car as a by-pass on the exhaust, so that by depressing a pedal the exhaust gases can be turned through the horn instead of taking the normal path through the silencer. The vibrating diaphragm of some horns is worked by mechanical means from the engine, power being conveyed by a flexible shaft.



Combination electric and bulb-operated horn. Either system can be used, according to the sort of sound desired.



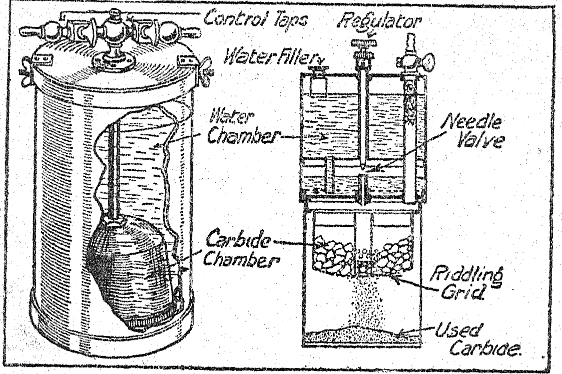
Hand-operated type of mechanical horn. A rack and pinion system of gearing causes rapid rotation of a drum containing rollers which strike a diaphragm.

Acetylene Lamps and Generators

Acetylene gas is an illuminant well adapted for motorcar lighting owing to its high luminosity and the ease with which it can be generated by bringing water into contact with calcium carbide (a compound of carbon and calcium prepared in the electric furnace). Calcium carbide is usually abbreviated to the word "carbide."

In the "drip" principle of generation the water is usually arranged to drip directly on to the carbide, and the amount of gas formed is regulated by a tap, which allows more or less water to come in contact with the carbide. A modification of this system allows the water to drip down a perforated metal tube surrounded with carbide, and thus the water gradually soaks through the carbide. All generators are now made specially with a view to ease of detachment, refilling or charging, and cleaning; this latter is specially important, unless the generator is of the "separating" type, in which the spent carbide is automatically removed from the unused carbide, as any neglect to clean out

the lime residue which forms, from the container, immediately after a period of use, renders cleaning a matter of considerable difficulty. Another important detail in working a generator is always to obtain the best quality of carbide, keep it in a thoroughly dry place, and tightly sealed up to prevent deterioration. When charging the carbide container, allowance must be made for expansion of the carbide when it becomes exhausted, so that only the amount advised in the directions supplied with the generator should be put in.



A

Simple form of diving-bell generator for acetylene gas. When the supply to lamps is shut off the pressure of gas in the inner chamber drives the water away from the calcium carbide.

B

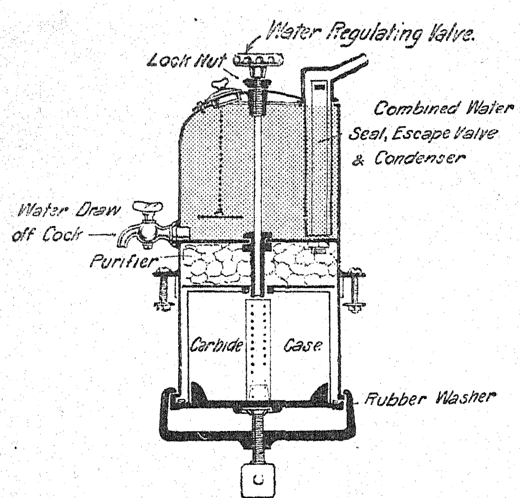
Drip type of shaking grate generator. The used up carbide shakes through the perforations into the base of the generator. The water tank forms the top part of the generator.

The Diving Bell Principle of Construction

This is adopted to a larger extent than the drip principle. In some respects it is simpler and gives a better regulation of the gas. In brief, the working is as follows:—The carbide is contained in a bell or chamber with perforated sides and bottom to admit water freely. This bell has a suitable outlet for the gas. It is supported inside an outer vessel or tank to hold the water. Immediately the water comes in contact with the carbide, gas is generated and, if the supply tap is open, this gas will pass on to the lamps. Should the tap be closed, the pressure exerted by the gas then acts inside the bell, and drives the water away from the carbide. Should the generation of gas still continue for some time, it will force its way through the water and escape into the atmosphere through a small vent hole, so that a dangerous pressure cannot develop within the generator. It will be followed that an automatic regulation of the gas is thereby obtained, because immediately more is being generated than can be used, the water is driven away from the carbide, but as soon as there is a demand for more gas the pressure inside the bell falls and water re-enters; there is a state of equilibrium the whole time.

The illustration A shows a simple generator. A metal water tank is fitted with a tight-fitting lid. The carbide is contained in a lower vessel, which is closed at the bottom and open at the top, having sides slightly cone-shaped as shown, and an upper inverted vessel—

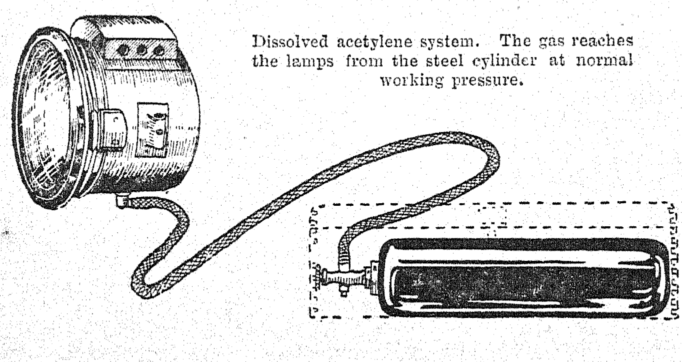
the sides of which are correspondingly cone-shaped—fits closely round the sides. The upper vessel is fitted with an outlet pipe, to which is screwed a simple control tap. So long as the tap is kept closed no generation of gas will take place, but on being opened, the water under pressure oozes up between the conical surfaces of the vessels and runs down the inner walls to the carbide, thus causing the gas



Section of a drip generator which can be taken apart easily for re-charging and cleaning.

to generate in the carbide chamber, whence it passes out through the outlet pipe to the lamp burner. The oozing action of the water is controlled by the balance pressure between the water head on the outside and the gas pressure on the inside of the generating chamber.

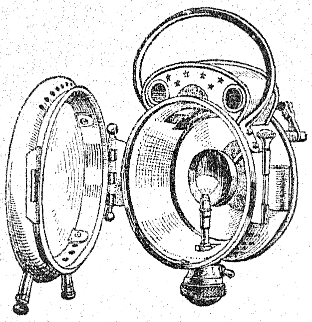
The chemical formula for acetylene is $C_2 H_2$ (i.e., a compound of carbon and hydrogen). It has a characteristic pungent odour—which at once gives evidence of any leakage—and is a poison if inhaled in any quantity. Approximately 1 lb. of good quality calcium carbide will generate six cubic feet of acetylene gas.



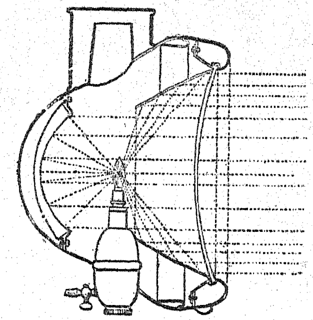
Dissolved acetylene system. The gas reaches the lamps from the steel cylinder at normal working pressure.

Dissolved Acetylene

This system dispenses with the use of acetylene generators, and for this reason, and its cleanliness and general convenience, is largely used, as the attention required is merely that of opening or shutting a gas control valve and changing the used cylinder for a fully-charged one. The acetylene gas is compressed in steel cylinders containing a preparation having the property of absorbing a large volume of the gas. The use of ordinary compressed or liquefied acetylene is forbidden by

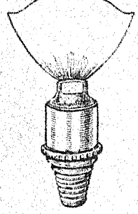


Autoclipse headlamp, fitted with no-glare device or non-reflecting disc, which can be dropped between flame and mirror, as shown.



Section showing general arrangement of an acetylene headlamp with back lens mirror and front parabolic reflector. The production of the parallel beam is also shown by the paths of the rays.

law on account of the inherent danger of explosion of the gas by concussion. On the other hand dissolved acetylene is exempt from this regulation, and may be regarded as perfectly safe to use. The gas is pure, and is passed through a pressure-reducing valve, so that it



Type of acetylene burner (Bray "Roni") giving a safe, flat, uniform flame, an improvement on the double-jet form of burner which risked cracking the mirror. The burner has an air-injector passage just below the slit at the sides. This prevents carbon deposit forming. Inside the burner is a pressure-check device which prevents flaring. The slot should be cleaned, if required, by passing a brush across it. Wire must not be used.

reaches the lamps at ordinary working pressure. The cylinders are usually mounted in a box carried on the running board of the car. The exhausted cylinders can be exchanged for charged new ones at numerous depots throughout the country.

High-Power Headlamps

It is usual to provide all high-power headlamps with a lens-shaped mirror as the most efficient means of collecting and focussing the rays from the acetylene burner and producing a more or less parallel beam. Some lamps have a cone-shaped metal reflector at the front and a condensing lens. Others are made on the "searchlight" principle, the front glass being plain, but made in sections or strips

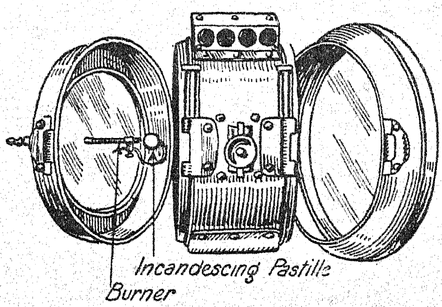
to avoid cracking by expansion with the heat. One of the drawbacks of the high-power headlamp is the glare which dazzles other road users, especially in passing through towns. To obviate this disadvantage, various attachments are fitted, one of the most effective consisting of a non-reflecting metal disc, which can be dropped between the flame and the lens mirror when it is desired to cut off the glare. This movement is effected from the driving seat by means of a lever and wire arrangement on the dash. Another system consists of a number of metal strips set horizontally across the front lens and screening the upward rays of light.

Petrol-Oxygen Searchlight

A lighting system which has been adopted to some extent is that in which a stream of oxygen at low pressure is passed through a "carburetter" containing petrol. This carburetter is a cylindrical metal vessel, in which the oxygen becomes impregnated with petrol vapour. The gas then passes along tubing to a burner, which allows a small jet of flame to impinge on a disc made of certain metallic oxides, chiefly consisting of rare earths, such as thorium. This disc is raised to a very high temperature and glows with great brilliancy, and with a very small consumption of oxygen and petrol a very high illuminating power is obtained. The burner and disc are readily adapted to any ordinary headlamp. The oxygen is carried in the usual steel cylinder of about 20 cubic feet capacity fitted with a pressure-reducing valve.

Oxy-acetylene Light

In this system a very powerful light is obtained by means of a jet of the combined gases directed on to a "pastille" of rare earths. This gives the theoretically ideal source of light for focussing and producing a long or a divergent beam. A less intense light can be obtained from an acetylene jet without the oxygen, but it is still a much more powerful light than a plain acetylene burner gives. The gases must necessarily be under pressure, the supply being obtained from the usual storage cylinders.



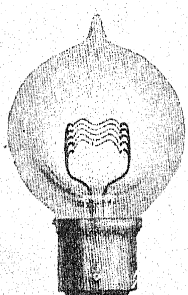
An example of an oxy-acetylene high-power headlamp, in which the flame from a jet of the combined gases is directed on to a disc or pastille containing rare earths, such as zircon and thorium oxide.

Oil Lamps

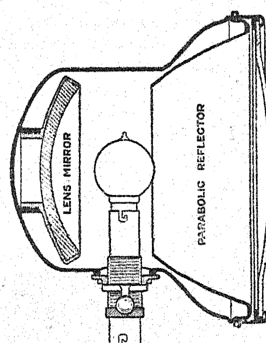
Oil lamps still find a limited amount of application, chiefly for side and rear lamps. These burn ordinary paraffin or kerosene, and are easily kept in order, and the upkeep of course is very small. High-power paraffin lamps, however, are now very little used.

Lighting in Foggy Weather

It is a remarkable fact that the most powerful lights, either gas or electric, have but a small penetrative effect in fog, and the acetylene headlamps of a car are at a similar disadvantage. It has been found, however, that an orange-coloured light has a much greater penetrative effect than a white or blue-white light. A plan now adopted is to place an orange-coloured glass or celluloid screen in front of the lens during fog. With electric light orange-coloured bulbs may be used, or the lamps may have "gold" reflectors inside.



Type of high-power electric lamp in which several filaments are mounted in a group to present an intense and compact source of light capable of being easily focussed.



Section of an electric headlamp, showing general arrangement of the mirror, bulb, and front reflector. This is a combination of the searchlight and parabolic principles of lamp construction.

Electric Lighting

The application of electricity to car lighting has developed enormously, and it is probable that it will eventually become the standard system of lighting on all types of cars. Practically every motor lamp-making concern is now supplying electric lighting sets, either exclusively or as supplementary to the making of acetylene lamps. In previous editions of this handbook it was explained how electric lighting on a small scale could be effected by the use of an ordinary accumulator, and by the conversion of the usual oil or acetylene lamps into electric by the use of fitments known as electric adaptors. Whilst the methods previously described are still applicable to those who do a limited amount of night driving and have facilities for recharging the accumulators, and who also do not desire to go beyond a nominal expense, most car owners will appreciate the great advantages of having a self-contained electric lighting set fitted permanently on the car.

The dynamo lighting set has now reached a point of very high all-round efficiency. Its output of current has been greatly increased: so that lamps of high candle-power can be run from it, and at the same time the weight, size and speed of the dynamo have been reduced. The only working component, apart from any special details that control the output, is the armature, and as this runs on ball bearings it needs very little attention beyond lubrication at infrequent intervals. The brushes and commutator are made very durable and accessible for adjustment, and at the same time the machine is thoroughly weatherproof. Since car manufacturers have in a large number of instances undertaken to provide the necessary accommodation near the engine for a dynamo, the one outstanding difficulty in the matter of installing such a set has disappeared.

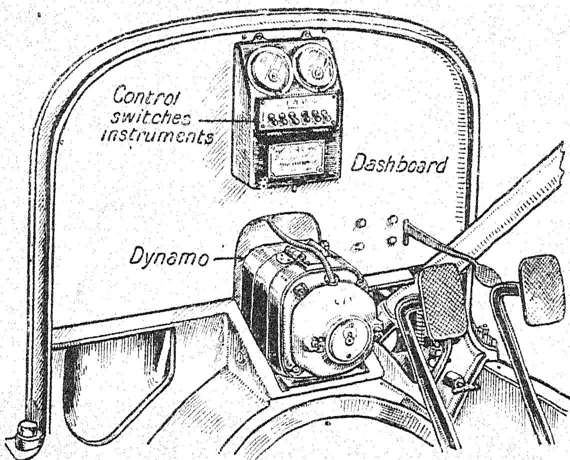
Lighting from a Dynamotor

The important characteristic property of a dynamo, namely, the fact that it can act as a motor if current be sent into it from an accumulator, is taken advantage of now in several machines designed specially for lighting and starting with a single unit instead of using a separate dynamo for lighting and a separate motor to start the engine. The single-unit machine economizes space, and in some instances is lighter than two separate machines. The one accumulator serves for the two purposes, viz., lighting and starting: although it is usual to employ a battery of 12 cells, giving 25 volts, and use half this voltage for lighting by adopting a three-wire system of connecting up the lamps. The full voltage is only required for the starting current, which may be anything between 50 and 120 amperes for a few seconds.

Principles of Modern Automatic Systems

There are many automatic systems available now, consisting in principle of a small dynamo driven from the engine, which, beyond a certain minimum speed, charges a battery of accumulators. Most of these machines have some special device incorporated in the design which keeps the output of current approximately the same through a wide variation of speed, and thus excessive charging of the accumulators is avoided. For example, a dynamo may be arranged to give a minimum output of 12 volts and 3 amperes at 800 revolutions of its armature per minute. At this speed it " cuts in " or closes its charging circuit automatically, then up to a speed of, say, 3,500 revolutions its output would not increase beyond 10 amperes, this figure representing its maximum output, which would, in fact, probably be reached at 2,000 r.p.m.; thus the current variations are not excessive, and any well-made accumulator is not likely to be in the least adversely affected. In theory the idea of the accumulator is simply to act as an electrical flywheel, the greater part of the lighting current being supplied by the dynamo and very little actually taken from the accumulators, except when the engine is stopped. As an example, the Rotax Leitner system may be referred to. It comprises a self-regulating dynamo of small size, which may be driven by gear or belt, a cut-out device and battery of cells. There is an auxiliary device, consisting of a combined switchboard, with charging ammeter and set of safety fuses. The automatic cut-in and cut-out may be had fitted on the switchboard if desired. The dynamo shown taken apart gives an output of 90 watts at a very moderate speed. The armature, which is of the slotted-drum

type, as shown, is mounted on ball bearings, and the machine is quite dustproof. It is quite free of working parts, there being merely the ordinary armature and carbon brushes, which are self-adjusting. The only detail that distinguishes it from any two-pole enclosed dynamo is the provision of an extra pair of brushes, and it is these which effect the automatic regulation. The extra pair of brushes form, as it were, a simple series connection between the two field magnet coils, the other or main pair of brushes being connected up as in any ordinary shunt dynamo. Expressed in simple terms, these extra or neutralizing



One arrangement of C.A.V. dynamo and control switchboard on the dash. The drive at rear of dynamo is taken from the camshaft of engine.

brushes draw off a current from the armature in direct proportion to the increase of speed which opposes the main exciting current, and produces a perfect state of balance in current output, so that it is impossible to detect any variation in the movement of the voltmeter needle. At very low speeds the auxiliary brushes aid the excitation of the field, but as the speed increases the armature distorts the field more and more, so that the auxiliary brushes work in a reverse field and reduce the main excitation.

The Position of the Dynamo

The mounting of the dynamo on the car may be effected in a number of ways. For example, it can be installed on a standard four-cylinder car in the space between engine and forward end of the frame, just behind the radiator, the drive being by gearwheels from the half-speed shaft, or it may be driven by belt from a pulley on the clutch shaft, in which case it would be mounted on a cradle or bracket bolted to the frame. The wires should preferably be carried in flexible metallic tubing, giving protection from wet and injury. The dynamo is arranged so that it never runs on open circuit when not required to supply lighting current. A two-way charging switch, when in the "off" position, automatically inserts a resistance in the dynamo field coils, which reduces the output to a very small amount.

A very simple type of lighting dynamo is one made on the elementary lines of a magneto. Instead of having wire-wound magnets it has a simple set of permanent steel magnets. Between the soft iron pole pieces there rotates a drum-wound armature with its commutator. The cut-in and cut-out device is mechanically operated. It consists of a small pivoted lever, which has a platinum contact at one end.

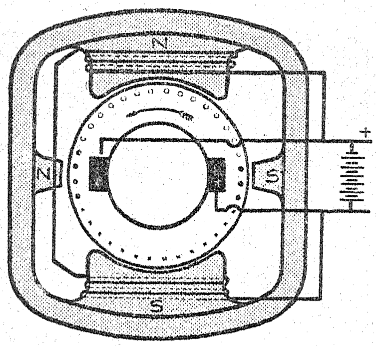
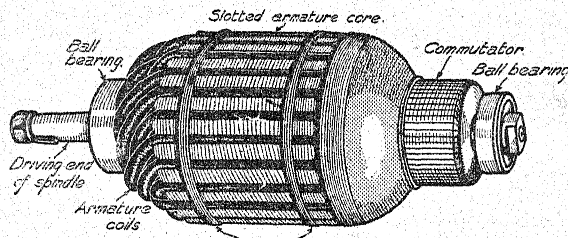


Diagram of field-magnet system and windings of a standard lighting dynamo. In this (the Brolt) system the two small unwound poles are used for output control. The series of horizontal lines between the positive and negative leads indicate the battery.

At a given speed the centrifugal force acting on the lever forces the contact against a fixed contact, and thus closes the circuit. This device is combined with the armature.

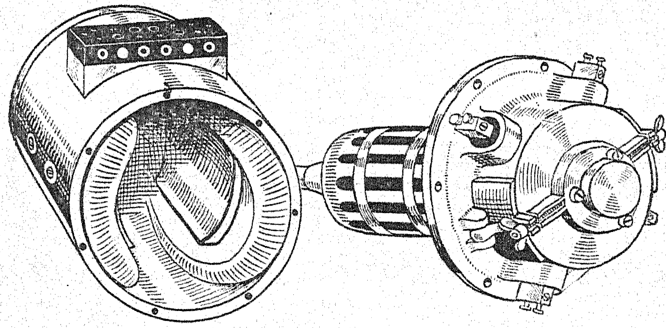
The shaft runs in ball bearings, and a pair of carbon brushes to collect the current complete the essential parts. This machine, whilst not giving so steady an output of current as the more complicated dynamos, has to some extent self-regulating properties, insomuch as what is known as "armature reaction," which increases with the



Drum-wound type of dynamo armature. The coils are wound in slots formed in the iron core, which is built up of stampings.

speed, tends to weaken the field of force. Moreover, the magnets themselves do not produce a variable strength of field as the electro-magnet does, so that it is found in practice that once a certain armature speed is reached the current output remains constant at any increase of speed. Another successful and simple form of dynamo has wire-wound magnets, but all complicated current control devices are avoided by making the armature run on a free wheel mounted on the shaft. On closing the charging switch, should the dynamo have not reached its excitation speed the armature simply "motorizes" till the back voltage from the cells is overcome by the charging voltage.

Automatic Systems



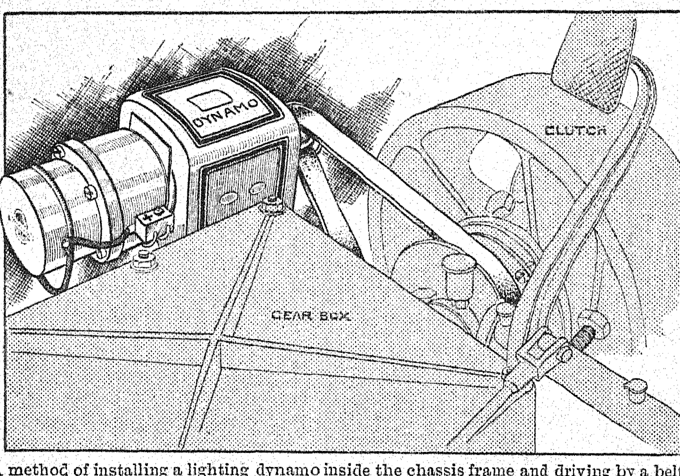
Enclosed field-magnet system of Rotax-Leitner dynamo. Drum type armature, end ball bearing and brush carrier. Also fitted with inspection plates to view commutator and brushes. A cover encloses all the brush gear.

Clutch Control

Of the various mechanical attachments to lighting dynamos, the clutch, in some form or other, is used on several types to prevent over-running. The clutch is adjusted so as to begin to slip at a pre-determined speed. The slipping action of the clutch is effected by centrifugal force, that is to say, it causes a slight withdrawal of the friction cone. This form of clutch is usually arranged in the pulley, and lubrication is provided for, so that wear and tear are reduced to a minimum.

Size and Output of Lighting Sets

Dynamos for car lighting have increased in output considerably in the last few years as the demand for greater lighting power has increased.



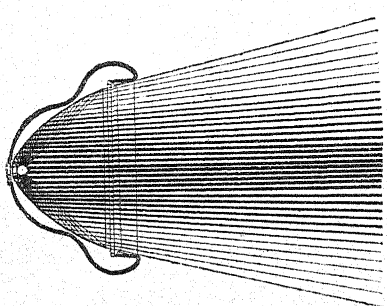
A method of installing a lighting dynamo inside the chassis frame and driving by a belt from a pulley mounted on the clutch shaft. A V-section driving belt is often used.

The smallest practicable sets now have an output of 50 watts, the largest reaching 300 watts. In cases where much night work is done, and very powerful lamps are required, a large output set is necessary, especially if the day driving is limited, as the cells thereby do not get charged except when the lamps are in use. It is important that the dynamo should always generate slightly more current than the lamps are actually consuming, otherwise the cells will be gradually exhausted of current. For a moderate power touring car of the open type a set giving 100-120 watts will give ample illumination if well designed lamps be used. Large, enclosed cars of the limousine and Berline type require higher output sets.

Switchboard and Lamp Control

Each of the many systems now in use embodies a specially designed switchboard, which is fitted on the dashboard of the car. This has fitted on it generally two instruments, an amperemeter and a voltmeter; the former indicating both the charging and discharging rates. Each lamp or pair of lamps has a switch provided, although there is also what is known as a "combination" switch used on some switchboards, all the lamps being controlled from one switch instead of

Parabolic Reflector

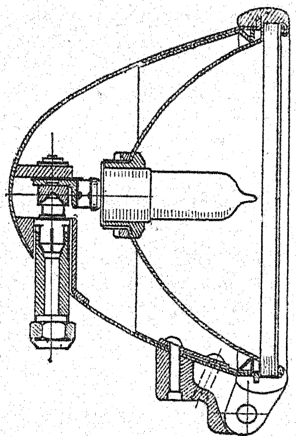


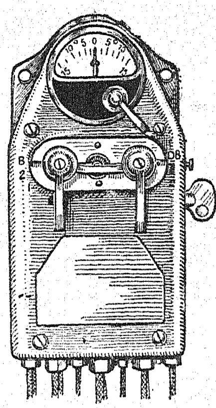
The light from the bulb is collected by the enclosing parabolic reflector and projected forward in a powerful beam, which gradually diverges and lights up the whole road. There are not two distinct beams, but the powerful central rays gradually merge into the soft outer fringe, thus providing a perfect driving light with a maximum range and a minimum of glare.

having a set of separate switches. This obviously simplifies the switchboard. Provision is usually made to connect an inspection lamp to the switchboard by an ordinary plug contact. The electro-magnetic cut-in device for the dynamo used on a number of systems is fitted inside the switchboard.

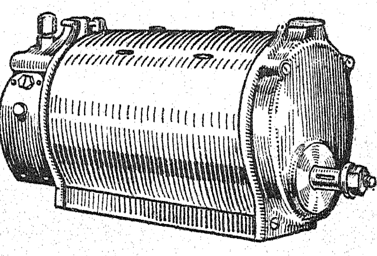
The Battery

The principles of an ordinary accumulator have been dealt with in the ignition section. Lighting accumulators do not differ very much in principle and manipulation. The dimensions are greater, and the number of separate cells used ranges from 3 up to 8, that is, 6 volts to 16 volts, the latter being exceptional, and only required for very powerful head-lamps. The battery is usually fitted in a box, which is mounted on the running board, but if there is room it can be carried inside the chassis on special brackets. Accumulators for lighting are now specially designed mainly with regard to the strength of the plates, so as to withstand the special conditions. It is not advisable to use ignition cells for lighting, as the plates are not strong enough.

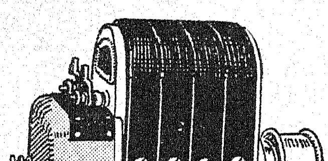


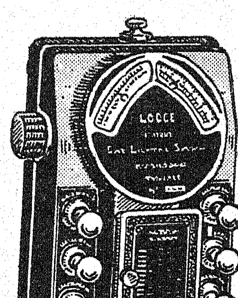


Bosch headlamp in section, and switchboard with ammeter.



Bosch constant voltage, variable speed, lighting dynamo.





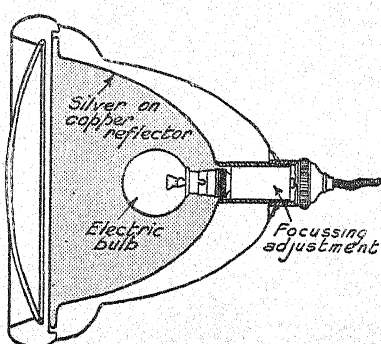
Lodge dynamo with permanent field-magnet system, switchboard with push-in switches, and illuminated ammeter and voltmeter.

Arrangement of Circuits

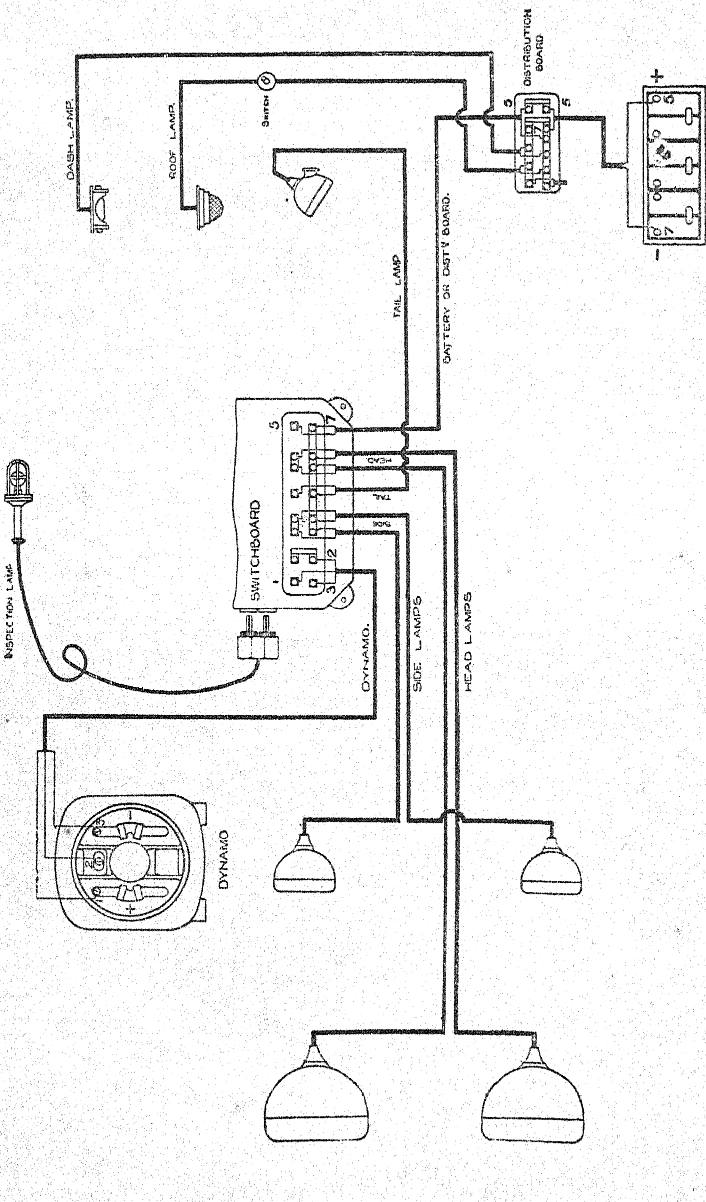
The wiring circuits of the many lighting sets vary in detail, though in principle there are several similarities. Each maker issues a wiring plan in the descriptive list of the set, and this has to be followed. With the exception of the rear lamp and its indicator lamp or "tell tale," which have necessarily to be connected in series so that the same current passes through each lamp, all the other lamps are connected in "parallel," i.e., each has an independent circuit from the main supply, and the control of one lamp does not affect the others. Thus it is possible at will to have one side lamp and one headlamp lighted, or both complete sets, or only one of each. Similarly, any interior or auxiliary lamps will have independent circuits, each forming a branch to the positive and negative main leads, which are brought into the switchbox. Here is usually to be found two brass or copper bars with a number of screws or terminals on, and it is from these that each circuit is tapped off. The application of what is erroneously termed the "earthed" system of wiring is based on the use of the outer metallic braiding over a single well-insulated wire as the return part of the circuit. This makes in some respects a neater system of wiring than the use of separately-insulated conductors, and the whole circuit has a lower resistance, which effects an economy of current, insomuch as all conductors cause some loss of current. The single conductor system, however, necessitates the use of special fittings, lamps and lamp-holders as compared with the standard system.

Constant-voltage Dynamo for Direct Lighting

Several car-lighting dynamos are now made that have such excellent voltage control over a wide range of speed that the lighting can be done direct from the terminals of the machine, in which case the battery, so far as it is a necessity, need be but a small size that will supply enough current when the dynamo is not running to light such lamps as may be required, such as a side and a tail lamp. Once the dynamo is running, the battery can be switched off, as the constant voltage of the dynamo ensures that the lamp will maintain a steady brilliancy at any speed the car is driven at. In some of the latest sets the battery is automatically switched off immediately it is charged up. This avoids the risks that arise from overcharging.



Section of a standard type of headlamp with parabolic reflector and focussing adjustment.



An example of a wiring system for complete set of lamps for a large car. Each thick line represents two conductors forming a complete circuit.

CHAPTER X

The First Steps in Practical Motoring

Considerations of Outlay, Storage, and Upkeep of a Car

To become a car owner and driver is, nowadays, a simple matter, thanks to the great simplification of car mechanism and its practically perfect reliability and efficiency. One may start motoring as a comparative, in fact an absolute, ignoramus on mechanical matters. The prospective motorist must, however, first study the question of finance. This is the dominating factor. How much can the prospective car owner afford to spend on a car and accessories, a certain amount for tuition in driving, etc., and accommodation of the vehicle? This all means a certain sum cash down. Then comes the question of future outlay. This bears a fairly constant ratio to the initial outlay. Large cars with considerable engine power necessarily mean a big price or initial outlay, the taxes on them are heavy, and the cost of maintenance is relatively large. A permanent attendant or chauffeur at a fixed wage is a *sine quâ non*, and then there are the items of tyre upkeep, fuel supplies, etc.

At the other end of the scale we have the small car with minimum outlay, with small running and maintenance costs and low taxation. The owner can quite well look after it and drive it, with, at the most, a nominal amount of outside assistance for cleaning. As regards accommodation, in either case the owner may provide it himself, but it is noteworthy that a feature of modern suburban house construction is the provision of a motor house to accommodate one and sometimes two cars. He may, however, be favourably situated in this respect, inasmuch as there is a stable or coach-house on his premises which can be turned to good purpose, or he may have a piece of ground he can spare at the rear of his house, and on which he can have erected a motor-house. This he can purchase ready-made in timber and galvanized iron, either new or second-hand, without any difficulty.

Private Motor House v. Garaging

A motor-house is not necessarily a fixture, so that there need not be any infringement of landlord's rights if the premises are not one's own. It stands to reason that the general type of car must be settled on beforehand if a motor-house is being purchased, and in some cases the two questions would have to be studied conjointly; that is to say, the prospective motorist may have a coach-house or outhouse of very moderate dimensions, and at the same time be very desirous of having the car under his own immediate control, in which case he would have a car to fit the accommodation available. The alternative is to increase the accommodation.

Then there is the method of garaging the car locally at a fixed sum per week, month, or quarter, or, what is often a more economical plan, is to look out for vacant stabling or coach-house accommodation at a convenient distance from one's home. In a fairly populous residential neighbourhood this is very often a simple matter, especially if one places a small advertisement in the leading local paper inviting offers of suitable premises on low terms. In negotiating with the owner, a clear and

definite understanding in writing as to the terms of letting such premises should be had, otherwise difficulties may arise at some future time. This is the case especially in regard to fire insurance. Suppose there are premises adjoining owned by someone else and a fire broke out, and perhaps wholly or partly destroyed the motor-house, the probability is that the owner of the property would seek to lay the blame on the motorist, and even if he did not, the insurance company would dispute any claim made on the ground that a motorcar was stored on the premises without an agreement being made with them as to risks.

Insure to Cover Risks

The owner of the car, in any case, must take risks of theft; many cases of private motor-houses being broken into and the car stolen have, indeed, occurred. It pays, therefore, to insure against theft, and also fire. Insurance policies are now so easily obtained to cover all risks connected with the driving and storage of a car that the car owner should not hesitate to take one out.

With regard to garaging a car, it is necessary to use judgment and care before entrusting one's property. There are garages, and places called garages, which do not at all justify the title being applied—the word "shanty" would, indeed, be much more applicable. One likes to know that the car is properly under cover, and placed where it can be got at with the least delay. Furthermore, it is only exercising ordinary prudence in settling on a garage for the car to choose a reputed and well-established concern rather than—for motives of economy—risk putting up at a place of the "here-to-day-and-gone-to-morrow" order. So far, so good; the prospective motorist understands that, with the necessary cash in hand, he can get the car and arrange for storage, etc., but he is then confronted with the problem what make and type must he get, and how is he to set about learning to drive it? The prospective motorist will find details of excellent cars of all types and prices in the advertisement pages of "The Motor" and in the special New Car issue published early in the year, and can note the names and types of those cars which are within his price, and, in asking for fuller details, it is always advisable to specify what sort of work the car will have to do.

For example, a medical man's requirements are not quite the same as those of a week-end motorist. The latter would take his car out, presumably mostly on fine week-ends, and select his roads. The former would require to use his car every day, in all weathers, and on all kinds of road, rough or smooth, level or hilly. The equipment would vary in the two cases, and a given sum can only be laid out to the best advantage by consideration of the respective requirements.

Learning to Drive

To learn to drive there are two courses open. It is best where at all possible to make an arrangement with the agent with whom the order is placed to have a short course of lessons on a similar type of car though it need not necessarily be the exact model. Many agents will do this for a reasonable sum, so that when the car comes along from the makers it can be driven and handled with a feeling of confidence which would not be the case had one learnt to drive on another type—probably very much out-of-date. The other course is to go to a driving school, but, like the garages, there are schools and schools—some give efficient instruction and have an adequate equipment of cars and fittings, others give but a poor return for the fees paid. In London and several of the large provincial cities there are well-established schools

of motor instruction, the advertisements of which appear regularly in "The Motor." Whilst a reputedly good place should be chosen, the pupil should refuse to pay exorbitant fees. The Royal Automobile Club, Pall Mall, London, S.W., has investigated the claims of most of the schools of motor instruction advertised in the Press and information regarding any of them can be had on application to the secretary. The would-be motorist, after ordering the car, should take out his driving licence from the motor licensing local authority for the county he resides in, usually at the town hall or council offices in the county town (even whilst learning to drive on another car he must have a driving licence), obtain a registration number from any county authority, get a pair of plates made, and the number painted on, so that he can fix them on the car as soon as it arrives. Finally, he must pay the revenue tax (see scale of taxes) immediately he takes delivery of his car. He can obtain an official form and pay the tax at any money-order office, although, in many cases, the local registration authority can issue such licences.

Choosing a Suitable Car: Features to Consider—What is the Work Required of it?

This is one of the first questions to be answered. For pleasure purposes only a standard type of body may be chosen, but for business uses the selection is more restricted should any particular requirements in the matter of accommodation have to be met. Then the county it is intended for use in is a great consideration. Confined to any particular district, a car with a given gear and engine power may be advantageously adopted which would not give perhaps *universal* satisfaction. Thus in a flat district a low-powered car will do efficiently and infinitely more economically what in a hilly country would necessitate perhaps twice the power to do the work at all. Most cars will "climb any hill," for instance. True, but this may mean only at a slow pace, which becomes too tedious in a really hilly district. Whether it is intended to keep a mechanician to look after and drive the car, or whether the owner proposes to do either or both of these things himself is another point to be considered. There is a limit to the size of car which an owner can, if it is in constant use, attend to in all respects *personally* with success, unless he be a man of leisure and, moreover, keen enough to put up with much of the drudgery involved. To obtain the best results in running and the greatest economy in upkeep, and it must be remembered that constant attention must be paid to a car when it is at home, and where the average man can easily find time to do ample justice to a moderate-sized car, a large one might be too much for him in the amount of attention required.

Cars for General and Touring Purposes

These comprise vehicles which meet the requirements of professional men such as doctors, inspectors, surveyors, and so on, ranging from the smallest two-seater of 8-10 h.p. to cars of from 15 to 30 h.p., and passing by easy stages to larger and more powerful touring cars capable of accommodating perhaps eight passengers and their personal baggage and of maintaining a high average of speed. Whatever type be decided upon for purposes such as are under discussion, a maximum of strength and a low weight are cardinal points to keep in view, so long as the former is in nowise sacrificed to ensure the latter. Light weight in proportion to power is one of the most important factors in determining the hill-climbing capabilities of a car, hill-climbing being, in this country,

the great test of efficiency. A moderately long wheelbase gives a more handy car than does some of the types which the modern form of body has called into being. These very long cars are unwieldy on narrow roads and at awkward turnings, and, on the other hand, too short a wheelbase does not give the same smoothness of running and immunity from the tendency to sideslip that the happy medium does. Another feature to be avoided from a sideslipping point of view is any prolongation or overhang of the body behind the rear wheels.

What Type of Body is Most Suitable?

Putting aside for the moment the case of those who, from considerations of price alone, would confine themselves to a car of power and size suited for a two-seated body only, it is in many cases a better policy to have a four-seater. Though the back seats may only be used once in a while, they are, nevertheless, too often wanted if not there, and the advantages of being able to give friends a lift and of having plenty of room for luggage and parcels are well worth the extra cost, so long as the buyer can afford to pay for the slightly larger chassis, and perhaps a couple of additional horse-power in the engine. On most two-seaters of not very low power a light, detachable, rear single or dickey seat can be arranged for if specially desired, but this increases the cost considerably.

Body Can be Made to Requirements

Although many cars are sold with a standard type of body, a very general practice now is to buy the chassis only, and then have a body built to meet one's individual requirements by one of the many specialist concerns in body making. The design of bodywork changes quickly, and it is desirable to obtain the latest improvements. Minor ones can often be introduced during the course of construction of the body. The weight of bodies of any given type varies considerably, and when extra lightness is required the makers adopt special means, such as the use of aluminium to a considerable extent, as well as modifications in the design.

Protection Against Unfavourable Weather

The folding hood is the simplest and most serviceable form of removable cover, and, in combination with a glass windscreen and suitable side curtains, will transform an open car in a very few minutes into a tolerably weather-proof vehicle. Any form of windscreen and hood will detract from the speed of a car, but, by reason of its lightness and convenience, the Cape hood is the best all-round protection to adopt. Of course, the landaulet body, coupé, brougham or limousine may equally be fitted, but these all add considerably to the weight, and necessitate a proportionate increase of engine power.

The Scuttle Dash

The introduction of the deep scuttle form of dash has increased the degree of comfort obtainable for the driver and front passenger, whilst for the owner-driver who wishes to have complete protection the all-enclosed body, in which the steering wheel and gear-change lever are inside, is in every way suitable. For open cars during fine-weather work a windscreen protecting the rear passengers is now much used. This prevents the eddies and side draughts so much felt when only a front screen is used. The streamline body with flush sides is now the standard for the open touring car.

The Question of Outlay

Here lies the crux of the whole matter, and when once the prospective purchaser has made up his mind to become an actual buyer, he should fix a price limit. With many people this fixes itself; that is to say, their means enable them to decide in a very short time how far they can go. In any event, to arrive at a maximum figure is the first step towards that process of mental "weeding out" which has to be gone through when so many and so great a variety of values are offered. Cars can be obtained at prices from £125 for a plain two-seater upwards, and in all calculations a sum of not less than, say, £20 for a small car, and so on in proportion to size, will probably have to be laid out in addition to the purchase price, in acquiring those accessories, spare tyres and tubes, tools and lamps, which are necessary, and all of which are by no means invariably "given in" with the car. The cheapest four-cylinder car to carry four would cost about £150, and from that sum upwards an immense variety of four-cylindered vehicles can be had, according to power, the average price for one about 15 h.p. approaching £300, though there are reliable cars of that power which cost less than that sum.

The Cost of Running

Closely allied with the important question of original outlay is that of running cost, which must be taken into calculation to a certain extent when buying. The size of the bill for upkeep bears, of course, a direct proportion to the mileage done. As regards fuel consumption, the item will not be found a large one in any car up to, say, 15 h.p., unless there is some radical defect in the system or temporary want of adjustment. In large and heavy cars the petrol bill quickly mounts up. The largest item in the cost of running is always that for tyres, and this charge becomes heavier as the speed increases, and is, of course, again directly proportionate to the mileage run.

It is not possible to give any reliable figures which would be generally applicable, although it may be said that to obtain less than 3000 miles from a rear tyre and 4500 miles from a front tyre is not a usual experience with careful driving, but the statement may be made that no man who can afford, according to his means, a car up to, say, 15 h.p., is likely to be frightened at the cost of upkeep unless he is very careless in his choice of a car, and, moreover, very unfortunate subsequently in the handling of it.

Petrol Consumption

The small 8 h.p. two-seater cars are the most economical. With a well-adjusted carburetter the average ranges between 35 and 40 miles per gallon, according to road and weather conditions. The four-cylinder 10 h.p. to 14 h.p. cars run from 28 to 35 miles per gallon, whilst the 14-18 h.p. four-cylinder cars range from 25 to 30 miles per gallon. Above this power, and including heavy-bodied, all-enclosed cars with full load of passengers, the consumption may be anything between 12 and 18 miles per gallon, according to circumstances. These figures must only be taken as a general guide, as so much depends on the conditions obtaining. With benzole used as a fuel, it should be remembered that these figures could be in most cases improved on.

Oil and Lubricant Consumption

The modern car, with its automatic oiling system for the engine, is very economical in the matter of oil consumption compared with the early hand or semi-automatic systems. It is not possible to give any definite consumption figures, but even on large cars it does not work out a heavy item in total running costs. Gearbox lubricant is not, as a rule, required to be renewed more than once in 2000 miles, and the solid grease used in various lubricators about the chassis is quite inexpensive. It pays to buy oil and grease, especially the former, in large quantities by the drum.

Replacements and Repairs

Excluding what may arise from accidents and improper use, the expenditure under this head should be nominal, certainly for the first season. For a medium-power car, say, 16 h.p., four cylinders, an allowance of £4 should be ample for 5000 miles. After the second season a general overhaul is advisable, but even after this is done the actual cost of any new parts should not exceed £8; this, in fact, is an outside estimate. In ordinary running the only replacements one has to consider are of a minor nature: one or two sparking plugs may give out, a valve spring may break or lose its tension; a few washers on the engine may have to be renewed, and other items of that nature; but the workmanship and material of the modern car are so good that actual broken mechanical parts are quite the exception.

Hints on Choosing Second-hand Cars

It is very often possible to pick up a genuine bargain in a second-hand car; there is a very large market to choose from, but the selection of such a car is a matter full of pitfalls and traps for the novice unless he is dealing with someone he knows personally and is acquainted with the history of the car, or a firm of good repute making a speciality of dealing in second-hand cars. It may be accepted as an axiom never to buy a second-hand car without it first undergoes examination and trial. There is no difficulty in getting an expert examination and test made by an independent specialist in this class of work from two guineas upwards. If circumstances render it necessary to rely on one's own judgment, and the vendor's statements, the latter should be clearly expressed in writing and signed by the vendor in case any dispute arises. It is, however, unreasonable to expect definite legal guarantees in the ordinary transaction.

A great deal might be written about the features of good and bad second-hand cars, but the following general particulars may be used as a fairly safe guide. It is most important to know the age and type, and whether the makers are still in business, with a view to being able to get any spare parts or special repairs done, apart from the fact that a type no longer made tells against a future sale. The bore and stroke of a cylinder should, if possible, be verified; the former, in any case, must be known to fill up the taxation form. Some idea of the nominal power of the engine can be got by applying one or other of the formulæ given in another section of this book.

Many buyers of second-hand cars have been deceived in the matter of engine power, and have found later on that what they bought is of lower power than they had been led to expect. Do not get an antiquated or ugly-looking model, as it will probably have to be sold again some day, and appearance tells much in its favour or otherwise. As to general condition—the gearbox should be inspected, and condition of gearwheels will show how much wear it has had. If chain drive is fitted

wear can be judged by the condition of the teeth and chains. The back axle should be jacked up and the wheels revolved to see that they are true in the running and firm on the bearings. The same with the steering wheels, and also the steering gear; any considerable amount of backlash is a sign of hard wear, but it is a defect which can be rectified. Tyres should be examined on the tread, and the size and make taken note of. Inquiry should then be made of the tyre makers, or their latest catalogue referred to, to make certain that the particular size of tyre can still be obtained. Some of the early-pattern cars were fitted with tyres of a size now obsolete, but there are not many of these cars offered nowadays.

The engine should be tested to see that it has good compression and runs fairly smoothly. Any knocking or rattle is a bad sign. It should respond easily to the ignition and throttle levers, and slow down to quite a small number of revolutions. The radiator system, tank, pump, etc., should be closely examined to see that all is tight and sound and no botched-up leaky places exist in the system. It should be noted that the water does not boil, as this would probably indicate a choked or otherwise defective system. Try all levers, pedal and brakes, and see that they operate—especially the brakes.

Examine the ignition system: if high-tension magneto, there is not likely to be much amiss should the engine start easily and run without misfiring; if the older system, see that the coil gives a good spark. Accumulators with a dirty, muddy interior is evidence of a bad condition. The fitting of a magneto and an up-to-date carburetter generally improves the running of a second-hand car.

The Hill-climbing Test

Finally, there is the best test of all—running the car with its full complement of passengers or equivalent weight in the shape of ballast. A *minimum* run of 25 miles should be made, with at least one really stiff hill on the way. The actual grade of this hill must be approximately known. It should be, for some portion at least, as steep as 1 in 8. A car which will not go up such a hill with some reserve of power available is of little practical use, except as a runabout on level roads. Note how the various gears change. They should operate quite smoothly and without any of that objectionable nerve-racking grind characteristic of worn-out gears. Try the reverse gear, and also see that one set of brakes is quite equal to holding the car on steep hills. Immediately after the run place your hand on the wheel bearings, and also those of the engine and gearbox, to note that they are fairly cool, showing that they are in good condition and well lubricated. The condition of the springing is an important factor, best judged by running over a rough or paved road. Very old springs often have no life or resiliency left in them. Too much importance should not be paid to the matter of polish and varnish about a second-hand car. The condition of the mechanism and its running capabilities, type and date are the true criterions of its value. The novice must remember that such things as aluminium paint, metal polish, leather revivers, and coach varnish may cover a multitude of sins—otherwise serious defects in the vitals of a car. It is very often well worth while, if a second-hand car is found quite satisfactory as regards the engine and transmission, to send it to a coach-builder for repainting and varnishing, and, if necessary, re-upholstering. The result will be found to justify the expense.

As to the price one should pay for a second-hand car, it is impossible to lay down any rule. This is a point where expert examination is most useful in determining the value.

Preparing a Car for the Road

It is not proposed here to deal with the question of the "general overhaul," because, in the best sense of the term, this is a workshop job, to be tackled only by skilled mechanics. It is not unusual for a car owner, whose experience extends over a season or two, to ask a motoring acquaintance if there is anything he ought to do to his car before he takes it out for the first run. It will be assumed that the car is not a new one. It may be a second-hand one or one that has not had any special attention since sent out by the makers. The chances are a hundred to one that the answer he will get will be that "he ought to give it a general overhaul." What this really means is that practically every working part would have to be dismantled, dissected, and closely examined to see that everything is in normal condition. This is not the sort of process a good class modern car should need subjecting to under three seasons' use at least, and even this is not saying that it is then an actual necessity.

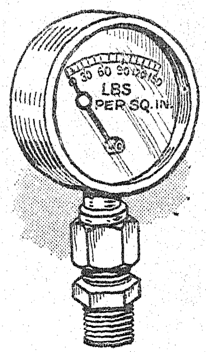
What it is proposed to convey is probably best expressed by the phrase "going over the car," although this term is somewhat elastic, according to whether the car owner has had some mechanical experience or otherwise. There are, of course, a large number of adjustments on a car which require merely the application of common-sense and those invaluable qualities—care and method to carry out. There are other adjustments that are not exclusively workshop jobs, but nevertheless necessitate some acquired mechanical skill to do properly.

Testing and Restoring Compression

We will begin with the engine, as this is far and away the most important component of the car. No engine ever pulled well with feeble compression, and in nine cases out of ten the compression as usually declared "good" would, if actually tested by a gauge, be found no better than "fair." This useful instrument, i.e., a compression gauge, is obtainable at any large accessory house. To use it, the sparking plug is unscrewed and the gauge temporarily screwed in place of it. A pull round of the starting handle will cause the compression to be indicated on the dial of the instrument. It should range from 75 lb. to 85 lb. if the engine is in good order. The condition of the valves—faces and seatings—should receive the fullest consideration. The A B C of valve grinding is dealt with in another section of this volume. When the work is thoroughly done, just test the edges of the valve caps when screwed down tight. With the finger smear a little thick gear oil right round the joint whilst someone pulls the engine steadily over the compression. Watch for air bubbles; if none appear all is well. If they do appear, loosen the cap, give the washer half a turn, and screw up again very tight. If the result is no better, take off the cap, and, with a well-paraffined rag, scrupulously clean all the contact surfaces; remember that a particle of hard grit may spoil a joint. It may be that new washers may be required to replace one or other that has deteriorated. The grinding in of the valves may be followed up with advantage by adjusting the valve tappets. Remember that correct adjustment makes for efficiency and silent running. A season's running will have caused the disappearance of the original adjustment. It is assumed that the tappets are adjustable, as every standard make of car should have them.

The rule for tappet adjustment is to allow the minimum clearance; this is to ensure the valve closing when it is working at its normal

heat. In obedience to the physical law of expansion of metals, a valve will be longer when hot than when cold. In practice it will be found that 1-64th inch space between tappet and end of valve stem will allow for expansion. If the clearance is too small, it will be quickly detected by the cylinder not holding compression when it is fully warmed up; as then the valve would be permanently, though slightly, lifted off its seat. As a suitable gauge a slip of tin, quite



Compression gauge for screwing into the cylinder, temporarily in place of the sparking plug, to test if the compression be strong or weak.

flat, and No. 28 standard wire gauge, will do nicely. Particular care should be taken to secure the lock-nut under the tappet cap, otherwise the advantage of delicate setting will be quite lost, as the cap will be liable to work round under the effect of engine vibration.

Gauging Sparking-Plug Points

It is desirable to take the sparking-plugs out, clean them in petrol—for this purpose a small stiff-bristled brush is best to remove carbon, etc.—and gauge the points. This latter operation is much more important than even some experienced motorists are aware of. It may never have been necessary to take a plug out in a previous season's running; nevertheless, they should come out on this occasion. All plugs *should* have adjustable electrodes, because the gap is prone to widen owing to fusing of the electrodes under the great calorific effect of the magneto spark. Some magneto plugs, however, have multiple electrodes which are not adjustable. Gauging should be very accurately done. It is not unusual to hear one motorist advise another to set the plug points to the "thickness of his thumb nail" or "of a piece of stiff brown paper." Take half a millimetre as the gap standard, get a small piece of sheet metal of this thickness and keep it. In the standard wire gauge No. 25 is just half a millimetre. Set the points to just admit the gauge friction tight. It must be assumed that the plugs are perfect. It is better to reject a doubtful one, i.e., one with signs of cracks in the insulator, defective packing (causing a "blow" or leak) or stripped terminal ends. Finally, test the seats with oil as done for the valve caps to see that the joint is compression tight.

The Magneto

From the plugs it is an easy transition to the ignition system in general. The magneto itself should require no more than a careful inspection of the make-and-break platinums. These should be tested

as to having the correct distance adjustment according to the gauge which most makers now send out with the machines. If no such gauge is to hand, use the half-millimetre plug gauge, which suits most machines. Some adjustment will certainly be required, and it is quite possible that the platinum contacts may require trimming. This may only be a slight amount, such as can be effected by introducing a slip of fine emery paper in between the contacts and drawing it through them a few times.

The Carburetter

The carburetter next claims attention, but it need not be assumed that it requires dismounting and taking to pieces. The needle valve on most carburetters is readily got at, and it will repay the time spent to regrind the valve on its seating with a touch of crocus powder, or rottenstone and oil. This done, the valve and float can be replaced, and the fine wire gauze filter or strainer generally fitted in the milled cap at the base of the carburetter carefully cleaned. This is all that should be required to be done to the carburetter, but it will be opportune if the throttle connections are just looked over, because it is not unlikely that some backlash may exist which can readily be taken up by giving the nipples on the ends of the control rods half a turn or so and securing them. Attention to this detail will ensure the throttle acting properly. A petrol strainer is provided between the tank and carburetter; this must be thoroughly cleared from grit and water.

The Lubrication System

The matter of regular lubrication to all parts of the running gear, and especially to the engine, is, of course, of prime importance. The difficulty, however, in dealing with it in an article of this kind is that there are scores of different lubricating arrangements, and one can therefore only say, whatever system is installed, see that it works. Should the car be an old type, fitted with exhaust pressure control of the lubrication, it is well to keep in mind the defects that are prone to develop. As the pressure is tapped off the exhaust pipe, to which the pressure pipe is connected by an ordinary screwed union, it will be a simple matter to make sure that the pipe is clear, by passing a stout wire along it a few times. Its weakness lies in choking up with carbonized oil. It is an equally simple matter to make certain that every oil lead to the various bearings is quite clear. By noting that the oil drips from the sights steadily and there is no accumulation of oil in the sight-glasses, of course it follows that the oil must be passing down the tubes. It is just as well to make certain that when the oil reaches the end of the tube it goes into the bearing intended. Leakage has been known to take place at the unions through these being slack, which meant that only a fraction of the oil reached the place intended. In cases where the oil supply is positively effected by pump, the same rules apply as to seeing that the tubes are clear and that oil is being actually pumped up to the sights. Most of the cars fitted with forced lubrication draw the oil from a sump in the engine crankcase, and it is necessary to see that there is an ample supply therein. An oil-level tap or indicator is usually provided. Some of the larger cars have a separate oil tank alongside the engine, which has to be replenished from time to time.

There are numerous parts on the car where periodical lubrication is necessary: these parts are usually equipped either with grease cups

or oil-holes. It will be needless to specify all these, as there is no difficulty in finding them. Some makers supply a diagram of the chassis with every part needing lubrication clearly indicated. Particular note should be made of oilers on the spring hangers, shackles, universal joints, steering pivots, knuckles, steering gearbox, and such-like, and an effort should be made to introduce some lubricant between the leaves of the springs. It can be done easily on some of the latest types of cars, as provision is made for it. On most cars, however, it means taking the load off the springs by jacking up the chassis in some way, such as with a pair of jacks and blocks of wood, and, if necessary, gently prising the ends of the leaves apart with a sharp-ended screwdriver and forcing in a suitable lubricant. The special tool for this purpose, illustrated in another section, is, however, the most convenient plan.

The gearbox and bevel gearcase on the back axle will have to be inspected as to there being an ample supply of lubricant, but *not* an excess. It is quite unnecessary to fill up the cases as beginners often do, and then wonder why gear grease floods out at joints and bearings and makes a fearful mess. There should be enough lubricant to cover the lower teeth of the gears; the rest will look after itself.

The Clutch

The clutch may want a little attention. If it is of the metal-to-metal type, it will require a proper amount of special lubricant in the casing. If it has been working badly, it will probably repay the trouble to drain off the oil and wash out the whole clutch with paraffin. The engine can be started up and run for, say, 10 minutes slowly, and then the paraffin thoroughly drained off and a correct charge of fresh lubricant added. As there are specially-prepared lubricants for the purpose, it is advisable to use what the car makers recommend. If a leather clutch is fitted and the leather-covered cone is get-at-able, it may, with advantage, be brushed over with at least one coat of Collan or castor oil and this allowed to soak in for 24 hours. If the clutch is of the internal type, one will have to be content with injecting a few drops of the oil through the small holes usually made for the purpose in the clutch drum.

Brakes

Some attention to the brakes is a matter of first-class importance. The countershaft brake—there may be two of these—should be adjusted as closely as is permissible; the blocks or jaws should just clear the drum, so as not to set up any permanent friction. There is no difficulty about this, as a screw adjustment is provided for the purpose. On many of the latest cars this adjustment may be done with the fingers only. Too much clearance on the brake blocks greatly lessens the efficiency and responsiveness of the brake, especially in an emergency. The steel cables actuating the rear-wheel brakes, which are found on many of the older cars, should be carefully examined for any signs of weakness or fraying of the strands. Particular attention should be paid to the clips which secure the loops of the cables. It may be found that some slackness in the cables could with advantage be taken up by loosening the clips, taking up the slack and making the clips secure again. On the modern cars steel rods are used instead of cables, and these can be adjusted by means of screwed nipples provided for the purpose.

The Tyres

What about the tyres? It is hardly likely that any but the most careless of car owners would have allowed these to remain neglected.

There may be nothing more necessary than the filling up of a few of the deeper surface cuts in the rubber with a tyre-stopping preparation. More serious damage can be repaired by means of a small vulcanizer. A valve may require a new plug or washer, or it may be necessary to replace a defective or leaking air tube, but nothing in the nature of a general overhaul should be necessary for the first two seasons. After that period it pays to take all the covers off, clean away rust, and re-enamel the insides of the rims. It is quite possible, however, that one or both driving tyres may have had such hard usage that it would be advisable to interchange with one of the steering-wheel covers. A weakened cover will, as a general rule, give a considerable period of further service mounted on a steering wheel, where it is relieved of driving strains and high internal air pressure. An alternative plan is to fit a detachable non-skid band over a weakened driving cover. Several good patterns, easily adapted and fitted, are now obtainable. A reinforced air tube may also be used in a weakened cover, or a "liner" may be fitted inside the cover. A temporary expedient is a "gaiter," which is either laced or strapped over the damaged part of the cover.

Cleaning out an Engine with Paraffin

A fitting conclusion will be to try every nut for tightness. If any of the enamel or paintwork on the body is chipped or damaged, it can be touched up with a fine brush and small tin of enamel. No reference has been made to a method one often hears suggested when preparing a car, and that is giving the engine a thorough clearing out with paraffin. This is rather a fetish with some motorists. They believe in putting a quart of paraffin in the crankcase every 600 miles or so, racing the engine, and then draining off. This method is not devoid of risk, for the simple reason that paraffin is so searching that it clears out every vestige of lubricating oil from bearings, cylinders, etc., and, unless one makes certain that every bearing and cylinder be properly relubricated before starting up again, a "seize-up," resulting in a costly repair bill, is not improbable. It is safer, therefore, for general purposes, not to use paraffin; if an exceptional case demands it, proper care should be taken in the treatment of the engine to ensure that no paraffin remains in the crankcase.

CHAPTER XI

Practice in Driving

General Instructions on Starting Up

Before starting, invariably note that the gear lever is set at neutral, thus leaving the engine disconnected from the transmission. This is highly important, as accidents have occurred owing to the car being in gear at starting. If there is any doubt on the point, a slight movement of the starting handle should be made, to feel that the engine is free. Then, assuming that the petrol and lubricating oil tanks have been re-filled and not forgetting the water circulation system if the car has not been used for some time, if necessary, and the petrol turned on, see that the carburetter is flooded by pressing down the float pin; have the throttle well open and the spark well retarded for the first trial, so as to lessen the risk of a backfire. The ignition switch, if one be fitted, of course, must be "on," then, by applying the starting handle and taking special care to pull the handle upwards with the left hand against the compression, instead of pushing downwards, so that if a backfire occurs no injury will result to the operator, the engine ought to start up. If it should not, the spark may be advanced a little and a sharper swing of the handle will be necessary to obtain a strong enough spark.

In cold or damp weather the injection of a few drops of petrol through the compression taps, or into the inlet pipe, generally facilitates a start. With an assured spark at the plugs, and an explosive charge entering the cylinders, the engine is certain to start up. Excessive flooding of the carburetter may render it difficult to get a start. In this case as much air as possible should be given at the air inlet to weaken the mixture. When the engine starts the throttle should be partly closed to prevent the engine "racing."

The "First Speed"

The lowest gear must always be engaged when starting the car from rest; and to ensure a gradual "take up" of the drive from the engine, the clutch should be let in very gently. (Read carefully details on manipulation of the gear elsewhere.) When increasing the speed, open the throttle to accelerate the engine, press down the pedal to release the clutch, and simultaneously put the gear lever on to the next speed, and quickly let the clutch in before the momentum of the car has become appreciably less.

Except when driving up hill, or in traffic where a very slow pace is temporarily required, the car should always be driven on the high gear or top speed. The important points to be attended to when climbing steep gradients are to keep the spark advanced, but not with as much advance as can be given on the level. The rounding of corners and bends must be carefully done, a sharp corner being taken with the clutch out and the foot brake gently applied.

Always see that there is a good supply of oil in the engine, and also carry a reserve supply both of oil and petrol. Two spare tubes should invariably be carried on the car, so that in case a tyre punctures the damaged tube can be quickly replaced by a new one. The tube should be carried in a bag or case to prevent risk of damage from tools. A spare cover should be carried on long trips; or, better still, a Stepney

or other spare wheel with cover fitted ready for use. Carry a really efficient tyre pump, and a handy jack for the wheels. See that the tool equipment is complete, and that the necessary spare parts for the engine, in case of emergency, are at hand, such as valves, plugs, springs, washers, split-pins, joint packing, repair band for tyres, etc. (See elsewhere list of spares, etc.)

Periodical Cleaning and Inspection of all the Running Gear

This is, perhaps, the best possible insurance against breakdowns when on the road. By undertaking this matter, small defects, such as a loose nut, cracked spring, petrol or oil leakage, or broken wire, are quickly detected before they can lead up to further harm. Brake work, being subjected to severe tests, and its efficiency at all times being of vital importance to the safety of the driver and his car, should be carefully scrutinised, and any adjustment of bands or tension rods effected.

Principles of Change-speed Gear Manipulation

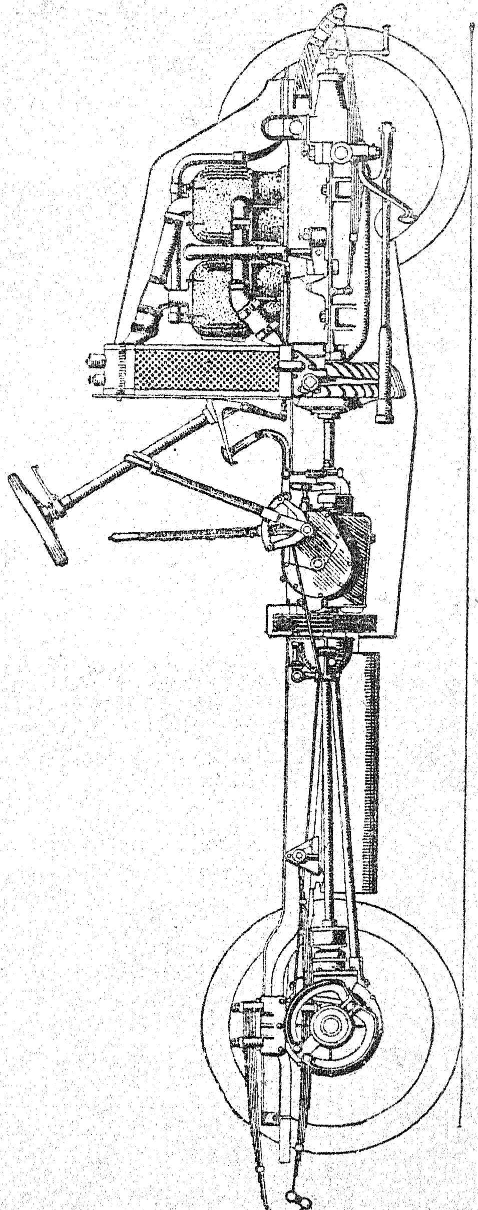
It is necessary to point out that the changing of the gear can only properly be learnt by practice with any given car. There are details in the manipulation which vary with every type of car, and it is only possible to give an outline of the principles governing the operations.

The most difficult operation in driving a car that presents itself to the novice consists in changing gear with ease. The quietness of movement attained by the experienced driver is envied, and the beginner endeavours to emulate it, sometimes with success; but more often his efforts are attended by a jarring and grinding of the gear teeth which is not alone painful to listen to, but results in serious damage to some of the most vital portions of the car mechanism. As the Panhard or selective types of sliding spur-wheel gear are now used, these notes may be considered as applying to these only, and in defining the right and wrong way of attaining the desired object the full understanding of the principle of the gear movement will elucidate the reasons for noise when the clutch or change-speed lever are improperly used. The two shafts in the gearbox are called respectively the first motion shaft and second motion shaft: the power is transmitted from the engine via the clutch to the first shaft, and the gearwheels upon this, meshing with those of the second shaft, convey the motion to the rear axle by means of the cardan shaft. The teeth of all the gearwheels are rounded or eased off at the first points of contact with each other to ensure them sliding readily into position.

Avoiding Damage to Gear Wheels

Assuming that the engine has been started up, the driver has taken his seat, the change-speed lever being in the neutral position of the quadrant (free engine position); before the lever is moved, the pedal connecting to the clutch is first depressed : this disconnects the engine entirely from the gearwheels. If any attempt be made to move the gear lever, without releasing the clutch, the teeth of the gearwheels upon the first motion shaft might be badly damaged.

Occasionally the gearwheels will not mesh, and consequently the lever will not find its way into the first (or lowest speed) position of the quadrant. The usual plan, under such circumstances, is to ease up the clutch pedal very slightly, which, by giving the engine a slight grip of the clutch, moves the first motion shaft gently around : as soon as the movement of the shaft commences the clutch is disengaged, and it will be found that the first speed can then be got quietly into gear.



Side view of chassis of shaft-driven, bevel-geared axle, four-cylinder car. Cooling by thermo-circulation and fan-vaned flywheel. Radiator behind engine. This position provides the maximum of accessibility to the engine, carburetter, magneto &c., and is coming more into favour.

For the novitiate stage it is preferable to depress the clutch pedal as usual, having the lever in the neutral position, wait a few seconds to ensure the first motion shaft coming to rest, and then, but not before, try to move the lever forward: if the grating noise is heard it will be a proof that the first shaft is still revolving, and further time should be allowed for it to cease movement; whilst, if the gear lever will not enter or engage with the proper slot, but appears to jam, the teeth of the gearwheels are not in the correct position for meshing, due to the relative speeds not being right. The lever should be brought back to the neutral position, the clutch gently released so that the movement of the first motion shaft is again obtained, and the pedal again fully depressed.

The whole operation can be repeated until it is certain the first gear is ready to take up the work. The car is stationary, and to give motion to the road wheels two movements are made—one by the clutch and one by the change lever. It has been shown how the gear can be made to engage smoothly, and if care be used the clutch will gently take the pace up until the fastest speed (upon the lowest gear) has been attained. After the lever has been moved the clutch must not be suddenly engaged with a jerk and a bang, but the foot should be gently raised, so that the power is very gradually communicated to the rear wheels.

Letting in the clutch quickly (with car at a standstill) may stop the engine, strip teeth off the gearwheels, or skid the rear wheels over the road before they can secure effective traction; and this last effect may be emphasized if the weight is not evenly distributed throughout the car or the road is muddy. It must never be forgotten that the whole power of the engine can be suddenly thrown upon the gearshafts by careless usage of the clutch.

The Purpose of the Clutch

In considering the function the clutch has to perform, an analogy can be found in a thread suspended from a nail and arranged to carry a weight just a fractional amount short of its breaking strain, the thread being several inches in length. If the weight is dropped suddenly for just the length of the thread the jerking strain will certainly break the thread; but if the weight be taken gradually upon the end of the thread, it will be suspended for an indefinite time. So with the clutch: ease the strain gradually by its means from engine to wheel rim and it will continue to do what is desired; let in the clutch suddenly and something may break. The easing of the clutch and the careful use of the foot brake provide a ready means of car control in traffic without the necessity of changing gear frequently.

Assuming the driver to have eased in the clutch and started slowly off, there need be no hurry to hasten in with the second speed. Allow the engine to "speed up" considerably, and now try to change up. The conditions are somewhat altered from the first point of rest to movement. We have now to deal with a slowly-moving car, and we should endeavour to make it run at twice the speed without causing any noise indicating that the change is taking place. The change must be made with certainty and at the first attempt. The proper meshing of the wheels cannot be tried for, but they must be allowed to engage of their own accord; for when changing up, if the higher gear cannot be immediately attained, the car will lose its momentum, and when the second gear is eventually engaged the extra work put thereby upon the engine may stop it.

To change to a higher gear, the clutch pedal must be *fully* depressed, so that the clutch is entirely disconnected from the engine; when the

clutch is fully disengaged, but not a fraction of a second before, move the lever quickly and surely from the first-speed to the second-speed slot and engage the clutch; the movement may be very slightly accelerated beyond that advised for getting from neutral to first speed, but the movement must still be a gradual one until the clutch is fully home. A part of the preceding sentence, "move the lever from first-speed to second," is the stumbling-block to motorists who find trouble in changing, combined with insufficient depression of the clutch pedal. After driving a car for some time the operation of gear changing becomes in a sense automatic.

Changing Down Upon a Hill

For this the lever movement will, of course, be carried out upon a similar method; but for hill work the clutch must be disengaged sharply by the foot, and as the foot presses the pedal down to its limit of travel the hand is prepared to pull the lever back quickly to get into the lower speed, and the clutch can be engaged. For hill work the clutch requires somewhat different treatment from work upon the level, for the speed of the car is diminishing by reason of the resistance offered by the gradient, and therefore the clutch must be released sharply, the change-speed lever moved quickly, and the clutch again let in quickly, but without a symptom of jerkiness or harsh movement. If the speed becomes slow up hill, the change must be made with rapidity, and, perhaps, jerkily, when the engine labours and "knocks," or the car will come to a standstill; this can always be obviated by changing gear before the engine reaches that stage of weariness. It is important to bear in mind that under no circumstances must the "reverse" gear be brought into engagement till the car has come to a dead stop, otherwise there is great risk of damaging the gearing.

A Method for Obtaining a "Silent" Gear Change

A car owner who has made many experiments in gear changing recommends the following method, which enables anyone to obtain, after a little practice, a perfectly silent change, either changing up or changing down gears. Firstly comes changing up.

(1) From neutral to first gear.—Declutch, and wait for a short period (this varies with the type of car, but, generally, about 2 sec. will suffice), then *gently* push into first. (2) From first to second and all "up" gears.—Declutch, and push gear lever half the length of its travel, wait an instant, and then *feel*, i.e., push the lever *gently* into the next gear. So far all is straightforward. Now, as to changing "down." From a high to any lower gear.—1st: Bring throttle lever to about quarter open position, at the same time instantly declutch, and bring back gear lever *half* its travel. 2nd: Quickly let in clutch and slip it out again (this should be a sharp up-and-down action of the leg), thus increasing the layshaft speed. 3rd: Bring back gear lever smartly into the required slot. This is so easy that it can usually be done with one finger. 4th: Let in clutch and open throttle. Result: An absolutely silent change.

The secret of success lies in the first action, i.e., setting of throttle. This, however, must be ascertained by trial. The author of this method claims that it is infallible on all cars with the usual selective types of gearbox, and, after a little practice, the change becomes instinctive.

Careful Driving on Badly-surfaced Roads

The life of a car, to a very large extent, depends on the amount of care and good judgment taken in driving on bad or indifferent roads. When lengths of bad roads have to be negotiated speed should be invariably reduced to such an extent as will minimize the shocks and vibrations from the road as much as possible. They are bad for the driver and passengers, and equally so for the car generally. If nothing so bad as broken springs, bent or strained axles results, the excessive vibration gives rise to all kinds of worrying little troubles. It is a common experience to strike on stretches of newly-made or unrolled road. Such require negotiating with particular care. For short lengths of "unrolled metal" it is best to allow the car to run over by its own momentum and with the clutch disengaged.

Caution when Driving at Night

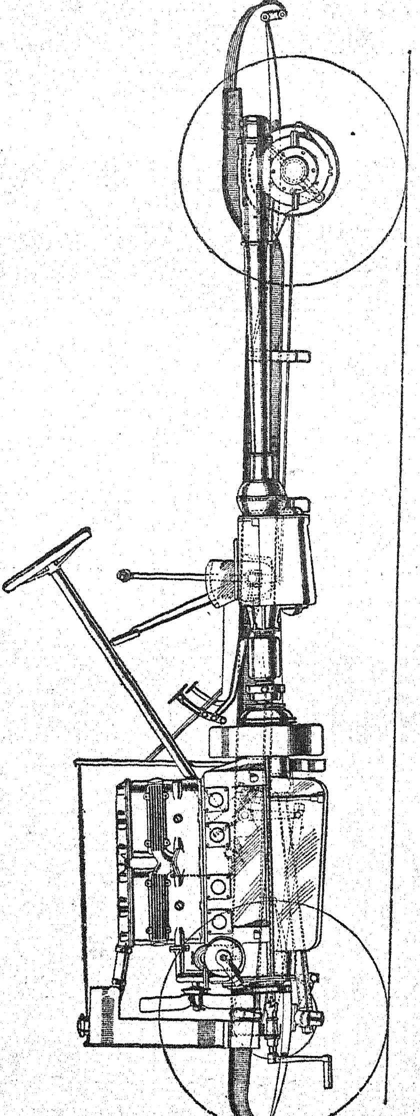
When driving at night and on unfamiliar roads it is hardly necessary to say that special care must be taken. When darkness comes on, the risks of accidents occurring through slight errors of judgment in driving are greatly increased. The driver must be on the alert for slowly-moving and lightless vehicles ahead of him, cyclists and pedestrians, and the amplest warning should be given of approach by sounding the horn. For the lightless country roads the advantages of having a powerful headlight throwing a beam well ahead and illuminating the road from hedge to hedge cannot be overestimated. In the towns, however, the use of powerful lights is to be deprecated, unless means are provided for temporarily screening the glare from the lamps.

Driving Round Corners

The necessity for driving round corners with extreme caution will be obvious. The speed should always be reduced very considerably; the sharper the turn, the slower it should be taken. When a car makes a curve the effect known as centrifugal force comes into play, and it tends to cause the car to lean over to the outside of the curve. The higher the speed and the heavier the car the more marked is this effect. and it proves rather disconcerting and uncomfortable for the passengers. To take an unbanked curve of small radius at high speed may easily result in the car capsizing, especially if the road surface is greasy. On a motor-racing track it will be observed that the curves are very highly banked, in some instances 40 ft., so that the centrifugal force is counteracted by the effect of the banking on the car exerting a force in the opposite direction to the action of the centrifugal force. On railway curves the outer rail is always elevated with the same object. When making a turn to the left, the car should always be kept well to the inside. When a turn has to be made to the right from a main road to a side road, make certain before turning that there is no traffic coming in either direction which would immediately cross the track of the car. Invariably sound the horn before turning. Never, if it is avoidable, pass another car at a bend in the road. A safe rule, when driving on a road which has numerous turns and high hedges cutting off the view, is to keep to the extreme left, sound the horn frequently, and reduce the speed so that in an emergency the car can be stopped dead in 20 ft.

Climbing a Hill on the Reverse Gear

It is well worth remembering that in many cars the reverse gear is considerably slower than the lowest forward speed. Should a hill, therefore, be met which is so steep that the car cannot manage to surmount it, or perhaps only do so by straining the car or dismounting



Side view of a standard type four-cylinder chassis with overhead worm drive, in which the driving shaft remains in nearly horizontal position. This gives more road clearance to the casing of the worm drive, and avoids the loss in transmission efficiency that would result from the shaft being set at a considerable angle.

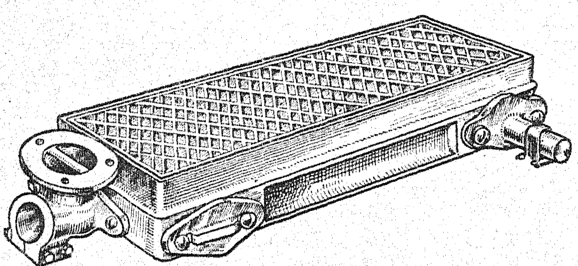
the passengers, it is probable that, by going up the hill backwards on the reverse gear, the difficulty will be surmounted. A further advantage is that, should the car by any mischance run back, it can be controlled better from the brakes and steering by allowing it to run forward in its normal direction.

Reversing in a Narrow Road

To reverse skilfully is an operation requiring practice; it cannot be learnt from a description. Moreover, circumstances are always arising when some variation in manipulation is called for. There are several methods, for example, of reversing in a narrow road, and the facility of doing it will depend both on the driver's skill and the amount of "lock" that can be got on the steering wheels. The beginner will be wise in choosing a fairly wide part of the road, or going forward till he comes to a side road to make his early efforts in reversing, and always bear in mind the rule to see that the road in the rear is reasonably clear of traffic or pedestrians.

Notes on Winter Driving

The speed of modern cars, even if driven well under their summer speed-rate, is such as to, of itself, entirely change the driving conditions as compared with horse driving, with the requirements of which we have been acquainted for centuries. Pictures of winter driving in the olden times, even with the horsed equipages of the last century, all combine to give the participating figures an appearance of red-nosed, shivering frigidity which is, to say the least of it, expressive. Yet in the incidents which these pictures are intended to portray the travelling pace was probably not more than three or four miles an hour. With the pace increased to four or five times and more this speed of progression, conditions call for very much greater protection of the person than was ever thought of in the olden time, and the heavy box-cloth coats and woollen wraps, with thick woollen mittens, adopted by our ancestors, would be but poor protection to-day against the biting blast of a north-easter, with temperature in the neighbour-



Exhaust heating device or foot-warmer, designed to be fitted in the floor of a car.

hood of zero and a 25 or 30-mile pace on the car. It is all very well for the driver; *he* has something to do which concentrates his attention and helps to keep him warm, but the passenger has nothing to do but sit still and shiver. Screens, either of glass or any other material, only half effect their purpose, as, whilst they protect the

occupants from direct contact with the air through which they are passing, they create a back draught which curls around and makes the whole body cold.

For passengers the only car for such weather conditions is a covered one, either one with a hood with side curtains well down, shutting the entire back of the car in, or the complete enclosure of limousine or landaulet. Both for passengers and drivers, more attention requires to be given to keeping the feet warm. Even in a closed vehicle the feet become uncomfortably cold.

In America, where excessively cold conditions are the usual ones during three or four months of the year, cars are put away for the winter more generally than in this country, but for the benefit of those who use their cars constantly, much greater attention is given to this important point.

Exhaust and Electrical Heating Devices, Foot-warmers

Quite a number of different devices have been adopted to keep the feet warm. There are the independent foot-warmers, which are filled with a combustible substance that will retain the heat for a considerable time, or with burning charcoal, and there are several ways by which the heat from the motor can be utilised to the same effect. In some cars a by-pass is made in the circulation system, which takes the hot water as it leaves the motor, or a portion of it, either through pipes, or a tank foot-warmer situated on the footboard; whilst by another method a by-pass from the exhaust deals with the exhaust gases in a somewhat similar manner by heating a foot-plate and with a cut-off arrangement handily placed so that they may be used or not as occasion calls. A refinement used on some cars provided with a dynamo lighting set is an electrically-heated steering wheel, the current being obtained from the battery. The rim of the hand wheel is wound closely with a resistance wire, and on switching on current to it heat is generated. The same principle has been applied to gloves, but as the consumption of current is considerable, the application of it is very limited.

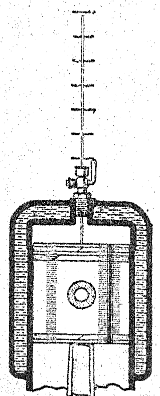
Such devices are very useful, but to be of use they *must be there*, and that practically means that they should be put there when the car is built. Now, in America, a motorist thinks of these things because he has to; but with us, seeing that cars are more generally bought in the spring or summer, when wintry conditions have passed from the memory, and as we often get quite mild winters, few people think of asking for anything of the kind.

The newcomer to motoring should purchase "How to Drive a Motor-car," published by Temple Press Ltd., which contains exhaustive instructions on all matters in connection with driving and the management of the car on the road.

CHAPTER XII

Various Adjustments to Engine, etc

The re-timing of an engine should, if possible, be done to a timing diagram supplied by the makers of the car. In many instances now such a diagram is included in the makers' instruction booklet. In other cases it can be had on request. The details of timing are more easily followed by considering one cylinder only, then it is a simple matter to understand that the remaining cylinders of a four or six-cylinder engine are timed in an exactly similar manner. The first important rule is that the timing must always be set, primarily, from the movement of the valves and not from the magneto contact breaker.



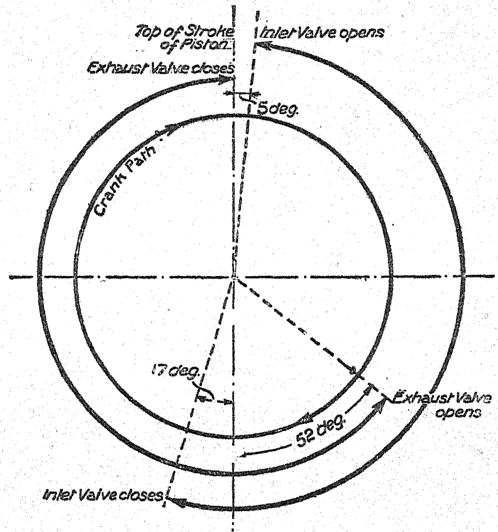
Method of locating the position of the piston by a wire passed through the compression tap opening, the highest and lowest points reached by the piston being indicated by the wire coming to rest momentarily when the engine is rotated slowly.

For effecting these timing operations it is necessary to find out the exact top and bottom of the stroke. On many of the modern types of engines there is no way of obtaining access to the top of the piston, but when this is possible, as in the case of a compression tap being provided in the cylinder head, it is a simple matter to unscrew this and insert a piece of straight wire, such as a spoke. Then mark upon it the beginning and end of the piston stroke with a file scratch. When the top and bottom of the stroke are determined, a centre punch mark should likewise be made on the inner edge of the flywheel to correspond with another fixed mark, such as a pointer screwed to the lower edge of dashboard. This should be done for each cylinder in turn.

Period of Valve Opening

In many engines it is possible to see the piston at the end of its stroke by introducing a small electric lamp through the valve ports or plug aperture. The actual period of the opening of the valves varies to a small extent according to the design of the engine, but the cams are always made to give at least an opening period of the inlet valve equal to the length of the inlet stroke, and the exhaust valve is allowed a period equal to a full stroke and an amount which varies from a fifth to a sixth part of a stroke; that is to say, it is open for the full period of the exhausting stroke and also for a part of the explosion stroke. This extra amount is termed valve "lead," and it is shown on the timing diagram as equivalent to 52 degrees of angular movement. This exhaust timing would give a very effective clearance of the exhaust

gases, but on many engines so long a period is not provided for. The inlet valve timing in the diagram is equal to just over the half circle, opening a little way beyond the top dead centre. On some engines the opening period allowed is rather longer, the object being to give ample time for the explosive mixture to flow in and fill up the cylinder. As the piston has scarcely begun to move upwards at the bottom of the stroke it is not found in practice that there is any forcing back and loss of mixture by delaying the valve closing. If the theory of the timing of an engine be thoroughly grasped, the practical part of the operation is very simple, and is only a matter of meshing the gear wheels correctly.



The timing of the valves and ignition of various engines differs to some small extent, the best setting being determined by experiment. This diagram illustrates the valve setting adopted in a standard make of engine. It will be noted that the exhaust valve opens well before completion of firing stroke and closes at the top dead centre, and inlet valve does not close till beyond the lower dead centre. Crank path is from left to right.

The Timing-gear System

The modern four-cylinder engine has a small gear wheel or pinion on the forward end of the crankshaft, which engages or "meshes" with a camshaft gearwheel of double the size of the crankshaft pinion. The procedure to set the exhaust valve is to bring the piston towards the bottom of the firing stroke, giving the requisite amount of "lead" denoted by a given number of degrees of flywheel movement short of the lower dead-centre mark. The camshaft should then be moved round till the exhaust valve of that particular cylinder is just being lifted off its seating. The camshaft gear wheel must now connect with the crankshaft by meshing its teeth with the crankshaft pinion. The crankshaft should then be turned round slowly in its proper direction of rotation till the piston reaches the exact top of its stroke, as indicated either by the mark on the piece of wire passing through the head of the cylinder or by the marks on the flywheel. If it be found that the exhaust valve has just closed

down on its seating at this point the timing is approximately right. If it has not quite closed, the camshaft should be advanced or set forward by one tooth. If it be found that the valve has closed considerably before the top of the piston stroke, the camshaft should be set back by an amount equal to one tooth of its gearwheel, and the opening and closing of the valve again checked with the piston movement. When the correct meshing of the teeth of the two pinions is determined, marks should be made on the face of the teeth, so that the timing can be set on any future occasion.

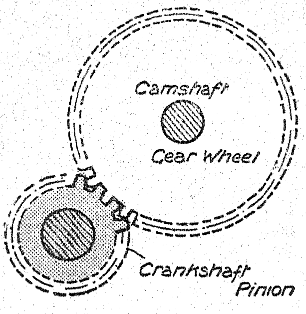


Diagram of valve timing gear of engine with single camshaft. This applies to the type of engine with all the valves on one side, and this system is the one used on the majority of modern engines. (In both diagrams the complete number of teeth on the gearwheels is not shown.)

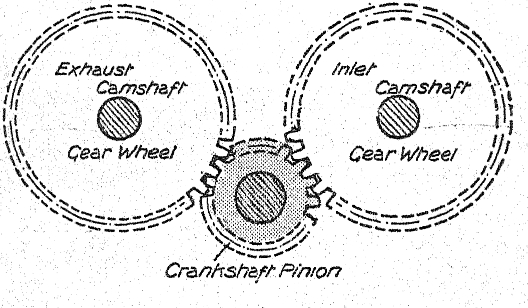
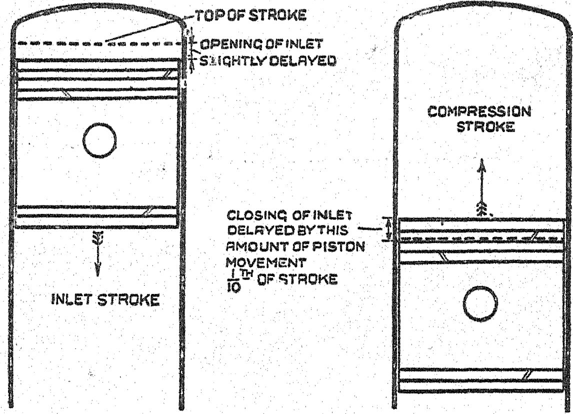


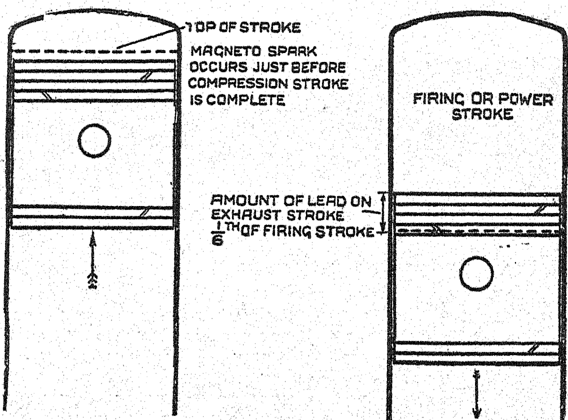
Diagram of timing gear of engine with separate camshafts.

Inlet Valve Timing

In the type of engine with the valves all placed on one side, both valves will be operated from the same camshaft, and it follows that if the exhaust valves are properly timed the inlet valves will also be properly timed, as the cams are placed in the correct relative position to each other, and any slight variation in timing can only be effected by adjusting the tappets. In engines with the exhaust valves on one side and the inlet valves on the other, separate camshafts are used, and the inlets must be timed independently to open just after the exhaust valves close. The closing of the inlet should take place just after the conclusion of the down stroke as previously explained. The procedure for the inlet timing as to the setting of the respective pinions is similar to that for the exhaust valve, the piston being set at the top of the inlet stroke or a shade later, and the camshaft set to be just lifting the valve. On turning the crankshaft round it should



Approximate positions of piston for inlet and compression strokes. It will be noticed that the inlet valve opens slightly late and closes late. This avoids risk of firing back and ensures a full charge being drawn into the cylinder. The amount of delay in opening the inlet valve however in some engines is less than the amount shown.

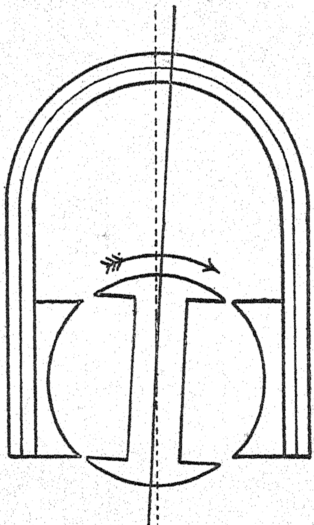


Approximate piston positions for beginning of explosion stroke and exhaust stroke. The early opening of the exhaust valve will be noted. The spark timing is supposed to be set at full advance for an engine of a moderate length of stroke.

be noted that the inlet valve about closes at the end of the down stroke or a little later. If one cylinder be correctly timed the other three will also be correct, assuming that the cams are all the same shape and unworn. The adjustable valve tappets, however, now usually fitted allow of the correction of any small variations in the timing of each cylinder.

Theory of Timing the Magneto

As the previous chapter on ignition will have made clear, the cam and contact breaker of the magneto are set in the correct relative position. The "break" of the platinum contacts is made to occur when the "cheeks" or segmental-shaped sides of the armature almost bridge the gap at the top and bottom of the magnet pole pieces. The position is not quite symmetrical, but the "maximum" or most favourable position



In timing an engine fitted with magneto ignition, the most important factor is to have the armature held in a maximum position, as shown in the diagram, wherein the armature has just moved a few degrees past the true vertical position. The contact breaker platinums should just separate when the armature is in a maximum position. In cases where the timing is fixed, this position should agree with the piston when about ⅛ in. before the top dead centre is reached.

is slightly in advance in direction of rotation of a vertical line right through the centre of the magnets and armature when the latter is set quite symmetrically. (The maximum position is shown in the illustration.) It will be found in most types of magnetos that the contact rocker has full retardation point, that is, the actual break between the platinums agreeing with the armature in this position of maximum effect. The reason is that, owing to the necessarily slow rate at which the magneto can be driven for starting, and as the spark has to be slightly retarded to prevent a backfire occurring, the most use must be made of the maximum position, otherwise there would be too weak a spark produced to ignite the mixture.

Setting a Four-cylinder Magneto

Taking as an example the Bosch magneto, described and illustrated in the ignition section, the ratio of the gearing between the crankshaft and the magneto spindle is equal to 1:1; that is, the armature must rotate at the same speed as the crankshaft. The correct method of timing is as follows:—The magneto must, firstly, be screwed down to its bed-plate on the motor, and the gearwheel, or coupling, which drives it, left loose on the spindle, if no keyway is fitted. If the gear-wheel or coupling is secured by a key instead of simply being tightened up on the taper, it is necessary to secure it firmly in its correct position before the magneto is screwed down, and in this case it is the engine portion of the drive which is left loose and tightened only when the setting is finished. The motor must now be turned slowly by hand in the normal direction of rotation until the piston of No. 1 cylinder—generally the cylinder next to the radiator—is towards the end of the compression stroke, and in the position of maximum advance at which the motor gives the best results. This position is usually marked on the flywheel, but, if not, it should be indicated by the engine manufacturer. While turning the motor it should be noticed whether the magneto rotates in the correct direction indicated by the arrow on the oil cover at the driving end. The next procedure is to turn round the armature until the figure 1 can be seen through the window of the distributor cover.

The lubricator on the distributor should be lifted right over in order to give access to another inspection window through which a view of the teeth of the distributor gearwheel can be seen. So long as the figure 1 can be seen through the window, it will be noticed that one of the grooves visible through the glass is painted red. The armature should be turned until this groove is exactly under the centre line of the inspection glass, and the timing of the magneto will then be quite accurate. The driving wheel or coupling can now be secured firmly to the armature spindle of the magneto by means of the nut provided for this purpose, but care, of course, must be taken that neither the armature nor the motor is moved during the operation.

Amount of Advance Possible

It has been found by experience that for the standard types of car motors a maximum advance of 35 degrees gives the most satisfactory results. If, therefore, the ignition is timed with this maximum advance of 35 degrees the spark will occur exactly at the top dead centre when the lever is fully retarded. If the engine will not take as much as 35 degrees advance, the piston must be brought within less than this distance (measured in degrees on the flywheel) from the dead centre when timing the ignition. For those engines which take a greater amount of advance, the piston, of course, must be brought further down on the compression stroke until it is at the correct distance from the dead centre, before the magneto is timed.

Setting Fixed Ignition Timing Point

This method is adopted on some engines so that no advance or retardation when driving is possible. The exact position of the piston at which to fix the contact breaker can only be settled by trial. A small amount of advance is usually possible, but it must be carefully regulated so as to avoid starting-up risks and knock when climbing hills.

Water Circulation Defects—Overheating

The up-to-date thermo-syphon system of cooling the engine with its large diameter and short passages for the flow of the water has practically eliminated the troubles that were frequent at one time, due to restricted water pipes. Radiators now are larger and more efficient in cooling capacity, and the absence of a pump liable to choke up or fail in some way from wear or a mechanical fault, has relieved the car owner from considerable anxiety. The complaint of "overheating," which is still a not infrequent one, may therefore be, as a rule, attributed to some other prime source than the water circulation. The term "overheating" is a distinctly vague one, and it is impossible to accurately define its symptoms, but if the circulation water has a consistent tendency to boil, it is safe to regard this as an indication that there is some abnormal circumstance giving rise to it.

Faulty carburation, i.e., too rich or too weak a mixture, is one well-known cause of overheated circulation water. The charge burns slowly and a much greater quantity of heat is transmitted to the cylinder walls than takes place during the rapid explosion of a properly-proportioned mixture. Another source of the trouble is a throttled exhaust; such as would be caused by a partly-choked silencer.

Mineral Deposits and "Furring" Up

The possibility of a restricted water circulation is, however, to be reckoned with, and presuming that there is no easily-located obstruction in the pipes, it may be the case that considerable incrustation of the system has occurred from the lime and mineral deposits thrown down from hard water. It is better to always use distilled, or well-filtered rain-water to avoid this, as such deposits are extremely difficult to remove. The only course is to circulate a strong solution of washing soda, 2 lb. to the gallon of water, through the system for at least 24 hours, but not necessarily in one period. It can be done in several running periods. Afterwards, the solution should be well-flushed out and the system refilled with clean water. Great care should be taken to prevent any of the soda solution coming in contact with the paintwork, varnish or leather upholstery of the car, as it has a destructive effect on them. It is also advisable to keep one's fingers from contact with it.

Cause of Steam Lock in Circulation System

Another indication of faulty circulation is overheating of the exhaust pipe a short distance from its junction with the cylinders. When this occurs it is usual to examine the silencer, with the view of finding if it is throttled, holes blocked up, etc. This is not often found to be the case, however; and, providing the valves have maximum lift, the probable cause is an overheated cylinder and valve ports. The water may not be circulating properly round the valve port. The formation of a steam lock is another cause of serious overheating. When this happens the water boils and generates pressure in the jacket, the water is forced back into the radiator, and the cylinder is run dry. Result: a seize up of one or other of the pistons. This is a trouble that should be carefully guarded against. A steam lock and back-pressure can also arise from the formation of an air lock in the pipes, usually at a bend in the outlet pipe from the cylinders. What

happens is that a column of air is imprisoned, perhaps during the filling up of the radiator. This column of air will stop the circulation, the water in the jacket boils and the steam forces the water into the radiator. The fitting of an air-release pipe on the outlet pipe and opening the small pet cock on the cylinder heads when filling up is a safeguard against this. It is important to have the system quite full of water. Defective or internally-frayed rubber connections between the pipes by restricting the bore will cause circulation trouble. These should be examined to see there is no internal defect.

Loss of cooling water is very often not so much due to boiling away as to a slow and steady leak somewhere on the system. Places that should be examined are pipe connections and pump glands. A good deal of trouble was at one time experienced with the type of radiator fitted to small cars. The soldered joints used to give way, probably due to insufficient support being provided for the radiator. It is very difficult to effect a temporary and effective remedy for a leakage of this kind on the road. A leak on a pipe, if it be get-at-able, can be effectively stopped by slipping a piece of rubber tubing over it and wiring it on, or, if the tubing cannot be worked on to the tube, it can be slit at one place and sprung over. A leakage of water from the jacket into the cylinder *may* be caused by a crack, but more usually will be found to be simply a defect in the seating of the plug fitted in the cylinder heads of many engines.

Radiator and Petrol System Leakages

The standard honeycomb radiator is somewhat prone to leaks; as the metal is very thin and the joints numerous, and it is not always possible to have a leak soldered up at the required time. In this case recourse can be had to a small but useful accessory known as a leak-preventer. It consists of a couple of small plates or washers with a piece of sheet rubber fixed on; these plates have hooks so that a spiral spring can be fixed on to draw them together. The spring is threaded through the aperture at the leaky cell, the plates hooked on, and thus held firmly up against it. Most accessory houses keep them, and if the car has a honeycomb radiator it pays to carry several of these devices. The construction of this type of radiator lends itself to a repair of this kind, but leaks in other forms of radiators, when they occur on the road, are rather troublesome. Even soldering them is by no means an easy job, there being such a large mass of metal that the solder cools as soon as it touches it.

A good plan is to carry a small box of white lead of a suitable consistency. If the water is not coming through quickly, a temporary repair can be made with this, especially if a piece of tape can by any means be bound over the repair. It is often possible to hammer up or plug a leakage in a tank or radiator. A temporary repair for a slight leak in a petrol tank can be made by applying ordinary soap. Such a repair may last till the defective part can be soldered. Leaks at petrol taps can generally be cured by screwing up the nut securing the tap plug, or by grinding in the tap with crocus powder and oil.

Attention to the Fan Belt

The importance of keeping the fan running at an efficient speed is rather prone to be overlooked. As those who have tried the experiment know, it is difficult to keep up the cooling without the fan running, especially in summer, and it is almost as bad to only have it running slowly. It will not do to assume that, because the fan is moving, it is doing its work efficiently when the engine is running fast. It

takes more power than one may imagine to keep a 14 in. or 16 in. fan running at from two to three thousand revolutions per minute, and if the belt is in the least slack or greasy, the fan will not run at its proper speed; slipping is going on all the time. The belt, if it does not automatically adjust itself by a spring on the bracket, must be kept reasonably tight and as free as possible of oil, although this latter is not easy to effect on some cars, owing to the oil which comes from the crankshaft bearing leaking along the shaft and being thrown on the pulley. A piece of sheet metal or fibre arranged as a screen between the bearing and pulley can be fitted to keep the oil away from the pulley.

Non-freezing Solutions for Water Circulation

To eliminate the risk of cylinder jackets freezing up and bursting in winter time, a non-freezing solution should be used instead of plain water. Such a solution consists of glycerine, preferably of the best quality—one part by volume, four parts water, well mixed before filling up the system with it. This solution is proof against 10 degrees of frost; one part glycerine to three parts water is proof against 16 degrees of frost. To compensate for evaporation, water only should be added. A mixture of alcohol (wood spirit) and water in the same proportion as glycerine mixture is frost-proof to about 12 and 20 degrees respectively. A mixture of one-third alcohol and two-thirds water is safe against even the sharpest frost that usually occurs in this country, and, on the whole, this is the most suitable mixture to use. It has the advantage of being cleaner and freer in use—the glycerine mixture is sticky and somewhat lessens the rate of circulation owing to its density. Moreover, the common quality sets up a corrosive action on brass and copper. The only disadvantage with alcohol is that it evaporates, and a certain amount of fresh spirit must be added from time to time to the solution.

As a precaution, when taking a car out on a frosty day, if it is necessary to stop the engine for any length of time, care should be taken to cover up the radiator and bonnet with a rug of some kind to prevent the temperature of the water falling too low, which may easily occur if there is a keen east wind blowing direct on the radiator.

Repairs to Water Jackets by Welding

The best plan is to take precautions against this occurring by using one of the non-freezing solutions described. There are very few cases where a cracked cylinder cannot be repaired by acetylene welding. There are numerous specialists concerns in this business now. In cases where it is not possible or convenient to have the damage welded by the oxy-acetylene system the following procedure may be employed:—

Four small holes are drilled and screwed in the jacket, and a piece of copper sheet well hammered down to shape. The holes would, of course, have to be made in the plate first and the positions marked off on to the jacket afterwards. Quite small screws should be used. A piece of tyre repair canvas should be cut to fix under the plate. This requires smearing with red lead and oil made to a thick consistency. If well shaped, and screwed down tight, this repair should give no trouble. The joint has no pressure to withstand, and there is no reason why it should not be permanent. The crack should be prevented from extending by drilling a small hole at each end.

Fitting a plate over a frost crack does not improve the appearance of the cylinder, although carefully repainting the cylinder makes the

repair less prominent. On the other hand, a welded repair cannot be readily detected, and the cylinder is quite as strong as when new. Small cracks may often be permanently sealed by cutting a shallow groove along the crack and filling it up with "iron cement," sold by the accessory concerns.

Oil-leakages on Old-type Cars

This is one of the defects which has been practically eliminated on modern cars, but many old cars are, however, primarily defective in the matter of retention of lubricant. The only real remedy is the fitting of oil-retaining glands to the ends of the bearings, although this, in many instances, is not an easy matter to carry out. The use of felt and leather washers can only be regarded as a temporary expedient, owing to the rapid wear which takes place within them. Loose and worn bearings, as will doubtless be sufficiently obvious, must accentuate the trouble, and this is really the first matter which should be investigated when oil leakage develops. The main bearings of single-cylinder engines, particularly should be kept in good order. Some leakages from gearboxes are largely the result of using too much lubricant.

Leakage from Rear Axle

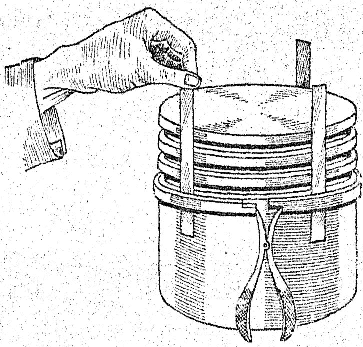
Excessive oil leakage into the brake drums not only reduces the power of the brakes, but the oil creeps over the drum, and is thrown by centrifugal force on the tyre. Metal-to-metal brakes, of course, are not intended to be worked in a dry state, as the wear thereby caused would be excessive. Too much oil, especially heavy-bodied lubricant, on the other hand, prevents the effective contact of the metal-to-metal surfaces. The source of the leakage may be found to be simply in using too much oil in the bevel gearcase.

The remedy, obviously, is to reduce the amount. If no cure is effected, the only course that can be adopted is the rather drastic one of fitting new felt washers in the axle ends, which is an operation for the repair shop, as, in any case, the wheels will have to be taken off the axle.

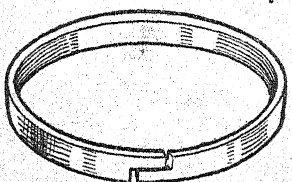
Removing and Refitting Piston Rings

The removal of rings is not difficult if a little forethought is taken: to open them, it is best to use a pair of very thin-jawed pliers, the jaws opening outwards; a substitute for pliers can be made from iron wire. When the ring is slightly expanded, a narrow slip of very thin metal—tin or brass will do—should be pushed through the opening and worked to the opposite side of the slot; then, if the ring is opened a trifle more, an additional slip of metal can be placed near each end of the ring, when it can be worked off quite easily and without any risk of breaking it, such as an attempt to expand it larger than the piston diameter would do. It is a good plan to mark each ring for its own groove, and also, when they are not pinned, to mark just where the slots should come on the piston.

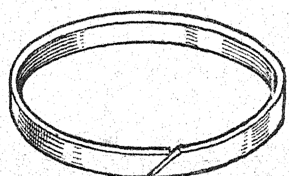
When the piston is in the cylinder, the ends of the rings should almost meet; the gap should close up to 1-32nd inch or less. In replacing the cylinder over the pistons, the rings should be closed up by means of a clamp. With an "en bloc" cylinder casting, expert assistance should be obtained, as the procedure is rather complex and not to be carried out single-handed. Should it be found that the piston rings have "stuck," owing to the accumulation of carbonized oil in the grooves, the whole piston should be soaked bodily in paraffin for about 12 hours. This will generally soften the deposit sufficiently to enable the rings to be removed.



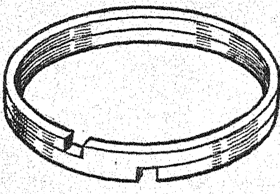
Method of removing piston rings from piston grooves. The ring is expanded slightly by special pliers or tongs. Strips of metal are then inserted under the ring at equidistant points, when the ring can be safely slid off. In replacing the rings the middle one is first fitted on over the strips, and then the other two fitted on from each end of the piston. Before a piston-ring can be removed, its gap must be increased until it measures approximately $6\frac{1}{2}$ times the average thickness of the ring. For instance, if the average thickness of the ring is $\frac{1}{8}$ inch, the gap will require to be just over $\frac{3}{4}$ inch. Some rings are concentric, *i.e.*, of uniform thickness. These tend to open out to an oval shape when expanded. In order to remove a ring of this type easily and safely, it is only necessary to increase the pressure of the finger and thumb at the sides of the ring in order to resist the tendency mentioned.



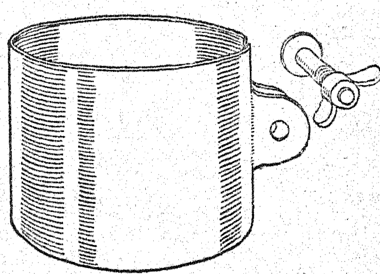
Piston ring with stepped joint which prevents leakage of pressure at the joint.



Piston ring with join cut slantwise. Easier to make than the other type, but not quite so effective in preventing possible leakage.



Duplex piston ring without joint, no leakage is possible.



A useful clamp made of thin sheet metal for fitting over the piston rings and assisting in replacing the cylinder. The clamp is screwed up moderately tight to compress the piston rings so that the cylinder can be gradually worked down on to the piston, forcing the clamp before it.

The Pinning of Piston Rings

If it is found necessary to pin a set of rings, it is the best plan to arrange the pins 120° apart, and then very carefully notch the ends of the rings with a very small round file, so that the semi-circular notches just close over the pins. Care should be taken that the pins are screwed tightly into the piston and do not stick out as far as the surface of the piston, since they would be very liable to damage the cylinder bore. As regards the fit of the rings in the grooves, they should just be a free fit, neither tight enough to bind nor slack enough to rock. Tight rings may be eased by grinding one of the edges on a sheet of fine emery cloth fastened to a piece of board planed quite flat. The ring is gently rubbed backwards and forwards with a downward pressure. After long periods of running, a deposit of charred, or partially charred, lubricating oil is liable to form behind the ring and interfere with its free movement: it is a good plan, therefore, when overhauling the motor to slip off the rings from the piston and thoroughly clean out the grooves with a sharp-edged piece of metal.

Reboring Cylinders

The closeness of fit of the piston rings against the cylinder walls is, of course, very important. As a rule, on modern engines the rings do not require renewing more than once in 20,000 miles, providing that the lubrication has been always efficient. After this distance it is the best course to have the cylinder bore tested for accuracy previous to fitting new rings, and if any appreciable inaccuracy is found to have developed, due to wear, to have the bore ground out true. New rings working in a worn cylinder will not retain the compression, and thus there will be an appreciable loss of power.

If re-boring be not decided upon, the rings, when on the piston, should be ground in by means of emery and oil, the piston being worked up and down in the cylinder by hand, using a short bar of wood placed through the connecting-rod big end to obtain a grip.

Cause and Remedy for Engine Starting Difficulties

Whilst it is true that, nowadays, to get an engine to start up with one or two turns of the starting handle is a very simple matter, even on a frosty morning, thanks to the great improvements that have been effected in the carburetter and the magneto, there is still an occasional instance met with, chiefly in the case of inexperienced car owners, when a start up is not easily accomplished.

A few words on the subject may, therefore, be useful, as, if starting difficulties do occur, the raw, damp weather of the sort associated with winter in this country is the most likely to produce them. If an engine will start up the first or second turn when it is warm, but requires an indefinite amount of handle grinding when it is cold, it is safe to conclude that it is the mixture which is temporarily weakened.

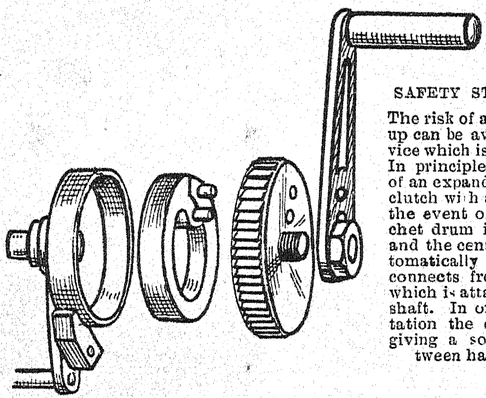
The magneto can, therefore, be left alone, because, if its adjustment be correct, no external influence will affect it adversely—with this one qualification: that if the car has been standing in a damp motor-house or garage for several nights, and assuming that the magneto is not quite the latest waterproof pattern, some of the moisture may have got into the distributor and caused temporary "shorting." Faulty setting of the plug points, i.e., too wide a gap, is a possibility. As previously mentioned, the gap should be ½ mm. to ensure a spark at starting.

As the distributor is so easily accessible, it can be examined and wiped dry if need be, but it is best left alone, except when the conditions are so bad as to necessitate attention. In a damp garage spots of condensed

moisture, or even a complete film of moisture, may collect on the insulators of the plugs. In this case, a rub over with a clean absorbent rag can be recommended. There is nothing further than these simple matters to be considered with regard to the ignition, although it may be mentioned that, if a switch be fitted, care should be taken to see that the ignition is switched on.

Enriching the Mixture

Concluding, therefore, it is simply a matter of getting the carburation right, that is, to obtain a rich enough mixture, the solution of the difficulty will be found in temporarily shutting off the auxiliary air supply at the carburetter. If this is not controllable, an expedient often used is to close the air port with a piece of rag or waste—a crude method, perhaps, but one that answers the purpose. A vigorous flooding of the carburetter by sharply depressing the float pin is indispensable in the obtaining of an initial rich mixture. All that remains now is to crank the engine sharply over; the more vigorously it be done, the more



SAFETY STARTING HANDLE

The risk of a backfire at starting up can be avoided with this device which is shown taken apart. In principle it is a combination of an expanding and contracting clutch with a ratchet drum. In the event of a backfire the ratchet drum is held by the pawl and the central clutch ring automatically contracts and disconnects from the other part which is attached to the engine shaft. In ordinary forward rotation the clutch is expanded giving a solid connection between handle and engine.

probable is it that the firing will be effective. If the engine is "stiff," a few drops of paraffin injected into each cylinder is necessary to enable the vigorous swing over to be obtained.

A Sharp Pull Necessary

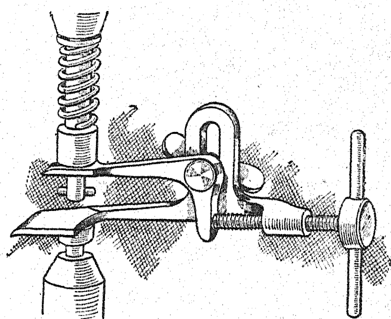
The reasons why a vigorous swing over greatly helps in starting are several. There is the strong suction caused on the jet of the carburetter, the petrol issues forth in a strong jet, and the high velocity of the air rushing past the jet atomizes or breaks up the liquid petrol into the finest particles, the air thus becoming well "carburated" and readily ignitible. Secondly, the explosive charge in the cylinder, in the act of sudden compression, becomes heated to a greater extent than it would under a slow compression; this also increases its inflammability. Thirdly, the spark from the magneto will be of greater volume and intensity in proportion to the rapidity of the armature movement.

Engine Stoppage Due to Air or Petrol Vapour Lock

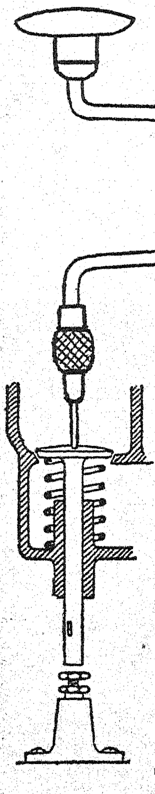
The trouble will probably be found to be an air lock having formed in the pipe. A small column of air becomes trapped in the petrol supply and forms a sort of cushion, which refuses to budge unless considerable pressure can be brought to bear upon it. The trouble will be more prone to develop in a long and unduly small-bore pipe with a number of bends or alteration in level. The only remedy is to rearrange or put in a new pipe with as unrestricted a run as possible.

Petrol Pipe in Faulty Position

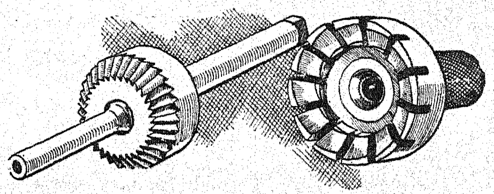
There is another phase of this trouble, but, strictly speaking, it is a petrol vapour lock. It will occur if any part of the petrol supply pipe is near enough to the exhaust pipe to become heated. The petrol in the pipe vaporizes and sets up a counter-pressure which effectually checks the flow of petrol to the carburetter. The remedy is obviously to bring the pipe to the carburetter another way and clear from proximity to the exhaust pipe.



A convenient form of valve spring compressor: the bell crank lever forces the spring away from the cotter by means of the screw.



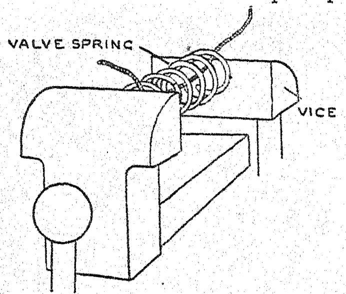
Method of grinding-in a valve. It will be noted that a small light spring is placed temporarily under the valve head, the purpose of it being to lift the valve from the seat when the pressure of the brace or screwdriver is occasionally released. This prevents scoring of the surfaces or formation of ridges by the abrasive material. Before grinding-in the valve should be examined to see that it is quite true. Several special valve grinding tools are now made which are more convenient than a brace, as the necessary backwards and forwards motion and downward pressure are obtained simultaneously with minimum labour.



Tools for truing-up valve seating and face of valve. The cutter on left is inserted in place of valve, and rotated with a brace. The hollow cutter is used by placing the valve in it and rotating it.

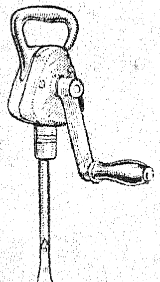
Removing Valve Springs

Both inlet and exhaust valves nowadays have very strong springs, and to remove them necessitates the use of a valve-spring compressor. There are any number of these devices on the market, but they are not uniformly effective by any means. Some of them slip at the critical moment, usually resulting in the operator damaging his knuckles. In some designs of valve-spring remover the principle is that of a pivoted lever, the fulcrum of which is taken on some adjacent part of the crankcase. A better form is that provided with a screw somewhat on the principle of a G clamp, the screw being



Simple method of compressing a valve spring between the jaws of a vice. Whilst compressed it is tied up with a loop of wire or string in two or three places. When the spring is thus tied up under tension its replacement is easy.

pressed down on the head of the valve or the cap, whilst the slotted lower limb of the G pulls against the cap holding the spring. There is no risk of the device slipping, which is likely with the other pattern. Another form consists of four bars of steel which can be pegged together to form a square. In the upper bar the screw is fitted, and the lower one hitched under the valve spring. It is very simple and adjustable to any type or size of engine in a minute or so, owing to the large number of holes in the bars allowing the pegs to be adjusted to any position. As a temporary or improvised spring lifter, a pair of large-size gas pliers with thin jaws may be used.



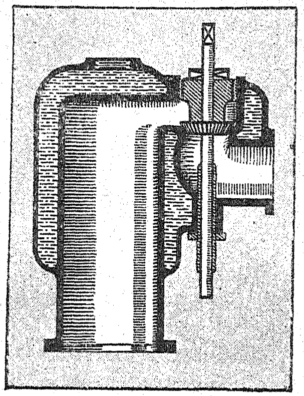
A convenient valve-grinding tool which reduces the amount of work. A rotary movement of the handle gives the valve a similar motion, but also an alternatively progressive one, so that the position of the valve is continually altering relative to the seating.

Grinding-in of Valves

When the face of a valve becomes rough and pitted, causing loss of compression, it is necessary to regrind it with flour emery and oil; a little of this should be placed between the valve face and its seat and the head worked briskly round—with a screw-driver placed in the slot the use of a brace saves time—till the surfaces become smooth. It is advisable to lift the valve off its seat occasionally in grinding. The valve during grinding-in should not be turned round continually in

one direction, as this tends to form rings or grooves on the surface. A backwards and forwards motion is best, the valve being frequently altered as to its position with the seating. Care should be taken to clean away any trace of emery from the valve passages to prevent it reaching the guides.

Only the finest emery powder must be used for this purpose. Most of the accessory houses supply a suitable grade, known as "220 Corn Emery." Carborundum powder of the finest grade cuts quicker than emery, and some motorists prefer it Only a touch of the grinding mixture should be applied, and unless the hint just given as to lifting the valve off the seating occasionally to change the position be followed,



Re-cutting a worn or badly pitted valve seating with a special tool. The necessary pressure on the cutting tool is obtained by a screw-down plug of hard wood fitted in the aperture over the valve. The plug is drilled in the centre to guide the tool.

a bad surface will be obtained. To finish off the surface, rottenstone and oil may be used. As to how often a valve should be ground in is a somewhat variable figure, but taking an average, once in 1,000 miles suffices for the exhausts, and once in 2,500 miles for the inlets, if the engine has had normal and careful use. When the valve face is badly pitted it should be placed in a valve truing tool (sold at accessory shops) and a new surface cut on it. A special tool is also made for truing up the valve seating.

Cause of Valve Pitting

Should the exhaust valves require frequent attention, it indicates that either the engine is being driven on too weak or too rich a mixture, or the exhaust gases are being throttled, which causes the valves to become much overheated. Throttling may be caused by the valves having insufficient lift or the silencer being choked with carbon deposit. An overheated valve will often be found to have warped. The head and stem should then be reset true in the lathe.

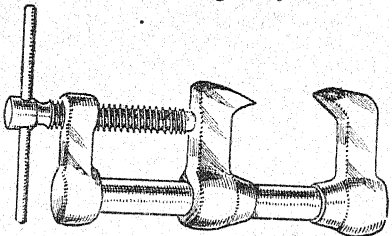
Care of the Steering Gear

To ensure efficient lubrication of the ball joints or connections of the lever arms, they should be protected by leather cases filled with grease. The leather case keeps out the grit, and only requires very occasional inspection and replenishment. All joints and pins left unprotected should be kept oiled constantly, and examined occasionally to make sure no lock-nuts or split pins have dropped out. All these connections are subjected to very severe vibration and shocks, and any worn pins and bolts should at once be replaced. If an obstacle is encountered, or anything in the nature of a collision takes place, the steering gear

should be the first part to be examined, and any repairs carried out at a competent repairer's. Everything depends upon these few levers and connecting rods of the steering gear.

Lubrication of Springs

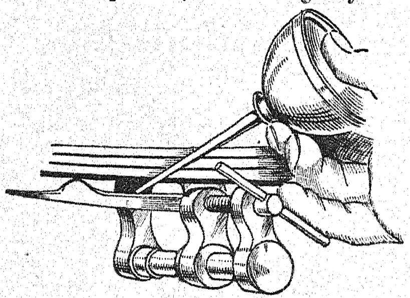
A detail which, if attended to, conduces much to the easy running of a car, is the oiling of those parts of the springs upon which the leaves move. It is becoming the practice to make provision for proper lubrication at this point, which is easily done by drilling a hole through each leaf, as otherwise it is not easy when the weight of the car is on them to introduce any oil into the interstices. Very frequently, however, rust is seen along the joints, showing that water can get in, at



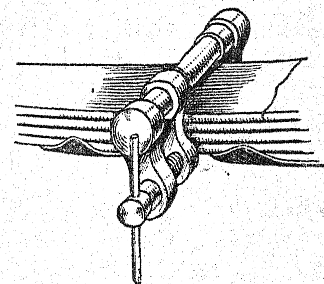
Special tool for separating the spring blades.

any rate, and oil will work its way in, too, if applied at the edges, but it will probably be found that this can be more efficaciously done if the blades are separated by means of the special appliance illustrated.

Rust in the springs affects their proper movement, and causes mysterious squeaks as well. The joints of the links connecting the upper and lower portions of the springs at each end should also have a little oil applied occasionally. It is when performing this duty that timely opportunity often occurs of observing defects of loose nuts in the neighbourhood. The nuts belonging to the clips which hold the springs on to the axle often display a tendency to work loose, and if this is not remedied the axle will be thrown out of line, with more or less serious consequences to tyres and driving gear generally; or, if the front axle is in question, the steering may be affected.



Lubricating the surface of the separated spring blades.



The same tool used as a temporary cramp to secure a broken spring.

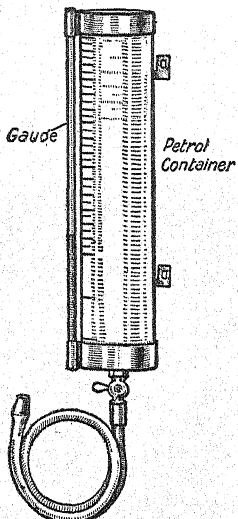
If a car is overloaded much beyond its normal capacity, extra work will be thrown on the springs which may give rise to breakage when the car is being driven over bad roads. An extra leaf added to the springs is advisable for overloads. Considerable advantage to the life of the springs is obtained by having shock absorbers or buffer blocks fitted.

Tyres and Rust

Rust has a very serious effect on the fabric of tyre covers; in fact, causing rotting of the fibres. Cars that have done much work in snow, slush and wet should at the earliest opportunity have the inside of the tyres examined for rust marks, and the inside of the rims repainted if there are any bare places. In any case, rims should be thoroughly cleaned and smoothed down at rough places and repainted at the beginning of the season. A slow-drying enamel varnish should be used in preference to the usual quick-drying enamel, which soon chips.

Falling Off in Petrol Efficiency. How to Make Tests

A question that is frequently asked concerns the gradual increase of petrol consumption which some cars exhibit after a moderate period of use unless carefully looked after. There may not be any very apparent reason for this falling off, the carburetter having been carefully overhauled, compression and sparking are quite normal, no undue friction is apparent in the transmission, all joints in the petrol-supply system quite tight. In such a case as this where the petrol consumption has become nearly doubled there must be some very marked reason for it. Leakages of petrol between tank and carburetter are commoner than would be suspected, and unless the examination is very thorough a leak may easily escape detection. A clue indicating whether the increased consumption is due to a leakage or a falling off in the general efficiency of the engine and transmission is to note the position at which the throttle lever has to be set for a given speed on



A mileage per gallon indicator, which enables a test to be made with a small quantity of petrol. The tube is attached to the carburetter temporarily, the instrument being mounted on the dashboard. For getting a new car into efficient running order this instrument is particularly useful.

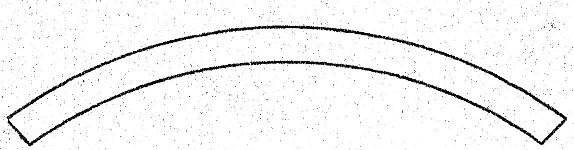
a known stretch of road. If a speed indicator is fitted to the car, a more accurate estimate can be made. Obviously, if the throttle has to be opened much wider than before to get the same work out of the car, it is evident that there is a waste of power going on somewhere.

Occasional tests should be made of the mileage which can be obtained per gallon of petrol under a given set of road and weather conditions. This shows whether the engine and transmission are maintaining their efficiency.

Fitting a New Leather to a Clutch

The smaller the angle of the cone of a clutch the greater must be the pressure and friction between the two engaging surfaces; the larger the diameter and the higher the speed, the greater will be the horse-power transmitted by a clutch. From these facts some of the causes of failure, whether it be due to slipping or fierceness, may be recognized. Thus, in a metal-to-metal clutch, the friction between the two members will be less than where the driven cone is faced with leather or some other suitable material. Consequently, the cure for slipping in such a case is to be found in providing for the fitting of a lining. It is assumed, of course, that the spring pressure is already as great as can be applied conveniently. It may be, on the other hand, that the angle of the cones is excessive, and this must be reduced slightly by turning in the lathe and fitting a thicker leather or some other clutch material afterwards.

Where a clutch proves too fierce, seizing its load too suddenly for comfort of driving, either the spring tension can be eased or the face



Shape of new leather strip, for covering clutch cone, as marked out from the old piece used as a pattern.

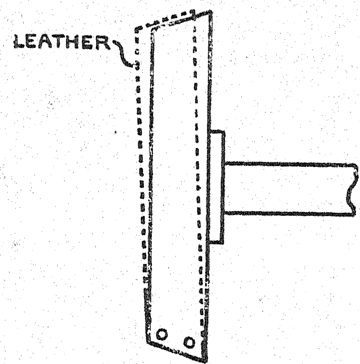
of the cone may be so treated that the co-efficient of friction is decreased. Generally this can be accomplished, in the case of a leather-covered clutch, by replacing the leather with one of the special wire-asbestos substances manufactured specially for clutches and brakes.

Dismantling the Clutch

The fitting of a new leather is a task which can be performed quite successfully by anyone possessed of ordinary workshop facilities. But, first of all, make certain that a new leather actually is wanted. If the existing one is but worn unequally, it is possible that truing-up will suffice to render the clutch serviceable again. Assuming that the clutch is one of the internal type, that is, the small end of the cone facing outwards, the clutch members should be taken down, and to do this have ready three long bolts of a similar diameter to those holding the outer clutch cone to the flywheel rim. Take out three of these bolts equi-distantly around the wheel, and substitute temporarily by the long ones, nutting up loosely. Now remove the remaining original bolts—there will probably have been not fewer than six in all—when the pressure of the clutch spring will be sustained by the three long bolts. Ease down gradually by slackening off the nuts along the bolts, and the clutch can be taken apart without any difficulty whatever. Subsequently the process can be reversed for reassembling.

Take the leather-faced member and bolt or "dog" it to the face-plate of the lathe, being careful to set it perfectly true. If the rivets holding the leather in place project at all, these must be filed or hammered down well below the surface. When hammering down any rivet, remember to hold the nose of another hammer hard up against the reverse end of the rivet.

A piece of medium-grade glass-paper, cemented to a wooden holder, may now be applied to the surface of the leather while running the lathe fast. This will very soon remove irregularities and charred oil. The surface can be finished by means of a smooth "sleeker" of hard wood or bone forced against the running leather under a liberal dosing of Collan or castor oil. Assuming, however, that a new leather or other fabric must be fitted, begin by removing the old material. Do this with the utmost care in order to avoid stretching or tearing the old covering, which will be required for a pattern or template. A good method is to take a sharp punch, such as is used by a saddler, and large enough to cover the rivet heads completely. Circles can then be punched out enclosing the rivets, and so releasing the leather quickly and easily. The small piece left behind with each rivet may, lastly,



An alternative method of fixing on a new clutch leather to cone. The ends of the leather, after being cut true, are riveted close up so as to require the leather to be forced on to the cone. The elasticity of the leather will enable this to be done. The holes are then drilled and the leather riveted up in the usual way.

be cut away and the loose rivet heads nipped off and the shank punched through. Should it be desirable to cut the new material into more than one piece, divide the old leather into the required number of pieces before detaching. The several parts will thus form absolutely true patterns. The new material, when cut to shape, should be fitted in position and secured for the time being by binding with string. Next, the necessary holes must be marked off through the corresponding holes in the clutch cone. On removing the leather it can be punched and the holes countersunk carefully by means of a small, sharp knife. Riveting on may then be proceeded with, and, this being completed, the clutch should be trued in the lathe and dressed as previously directed.

Remedies for Harsh and Slipping Clutches

Some clutches which become "fierce" only require treatment of the leather to effect a cure. One plan is to clean the leather with paraffin and apply a small quantity of a mixture of graphite and glycerine occasionally. Another plan is to fix under the leather a number of narrow slips of very thin springy metal such as brass or steel, say, eight pieces $\frac{1}{2}$ in. wide set at equal distances and given a "set" so as to cause the leather to expand slightly, and thus prevent too rapid engagement. A slipping clutch may require the spring tensioning or the leather cleaning with petrol. Collan oil should then be applied to make the leather supple. The use of resin should be avoided.

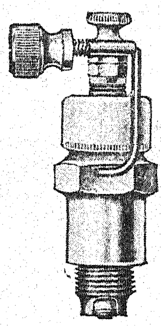
Choice of a Clutch-covering Material

A few remarks may be offered with respect to the choice of a lining material. If leather is decided upon, let it be a piece of "chrome butt." This is somewhat expensive, but it is practically everlasting. It possesses the further advantage of being less liable to stretch than ordinary leather. Nevertheless, it is advisable to wet and stretch any leather before making it fast finally. Materials such as Ferodo are preferred by many to leather, from the point of view of durability, especially as it is made moulded to conical shape.

Wear in Clutch Actuating Gear

The thrust washer inside the clutch must be examined and cleaned. If damaged in any respect renew it entirely. It is in the operating fork, clutch braking arrangements and other contiguous fitments that the closest attention will be required. Wheresoever there is shake or play due to wear it will be necessary to fit new pins, new bushes, or new slides. There is such an extensive variety of clutches and clutch-operating gears that it is impossible to do more than generalize in referring to the work of adjustment.

While at this part of the chassis, look to the layshaft carrying the clutch and brake pedals. It may need some adjustment at least. If the footplates of the pedals have become so much worn as to be smooth, it is a good plan to level them off by filing, and fasten upon each, with three or four screws, a plate of ribbed aluminium, such as is supplied for the covering of footboards. Moulded rubber covers are also obtainable for this purpose.



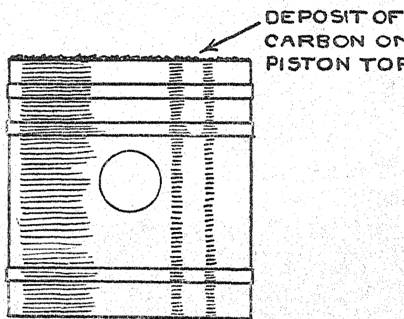
Switch attachment for sparking plug for "shorting" the spark when testing cylinders. This fitting is equally suitable for magneto or coil ignition. The plug, however, must not be kept "shorted" for more than a few moments to avoid heating the coil or magneto winding.

Methods of Testing Sparking Plugs

Take the instance of a four-cylinder engine with coil ignition, misfiring in one or two cylinders, due, perhaps, to a fouled plug. The principle of the test is to cut out three cylinders simultaneously by lightly depressing three of the trembler blades, by which action those three coils are switched off; by the beat of the one cylinder, call it No. 1, left firing, it can at once be determined if it is misfiring or not; then three more cylinders can be cut out, and No. 2 left in. and so on. Some coils are provided either with a short-circuiting button for each section, or a trigger which holds the trembler down at will—a very convenient arrangement. The test can be made single-handed; but it helps considerably if an assistant can depress the tremblers, as then the observer can pay more attention to the beat of the engine.

Causes of "Knock" in an Engine

Probably no trouble prone to develop in the engine is so difficult to locate and remedy as a bad and persistent knock. Every motorist of experience knows that an engine will knock or run with a hammering kind of noise by advancing the ignition beyond the normal working point for a given rate of revolutions, and he also knows that he can advance the ignition more when the engine is running fast than when it is running slow without knocking occurring. Advancing the ignition, even a very slight amount, with engine moving very slowly as at starting, results in a back-fire, and the knock is not so much heard as "felt." Too advanced ignition is not quite the same as pre-ignition, which, likewise, can cause severe knocking; but this condition must also not be confused with self-ignition, although both may occur nearly simultaneously. Faulty carburation, that is too rich a charge, or carbon deposit on the piston caused by over lubrication may result in pre-ignition. Strictly, a pre-ignition is a too-advanced ignition occurring without the agency of the spark. On the other hand, self-ignition, resulting from the same cause, may (and often does) occur at approximately the correct firing moment if the engine be running on about half throttle. A not uncommon experience is to find that, on switching off the spark and cutting off most of the gas, the engine fires with perfect regularity for some hundreds of yards, but finally misfires and stops. If the throttle be opened full whilst the engine



Illustrating the formation of carbon deposit on piston top.

is thus running, it generally results in a severe knock taking place. It is easy to follow why this is; more gas means higher compression, and the greater heat induced raises the igniting media to the critical point of incandescence earlier in the stroke. The trouble may still occur even after the combustion chamber and the top of the piston have been well scraped from carbon deposit. Small particles of carbon may remain concealed in the valve ports; the cleaning out should be as thorough as possible, using a scraper formed out of a strip of steel.

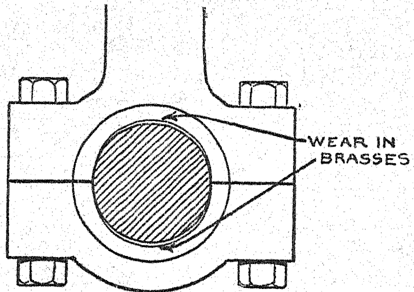
Another source of pre-ignition arises from a very small defect in the cylinder casting in the shape of a minute fin or projecting bit of metal, or a "wire edge" at one of the valve ports. The result is that the bit of superfluous metal reaches the incandescent stage under certain conditions and causes self-ignition of the charge.

Too High Compression

Some very puzzling cases of knock have finally been traced to the compression being too high, resulting not so much in actual pre-ignition as in too rapid burning of the charge. The charge could be compressed high enough to ignite spontaneously. With super-compression

of the charge instead of a gradual expansion of the ignited gases a "detonation" occurs. A reduction of compression often effects a cure in certain engines prone to knocking. There are two or three ways of doing this: the cylinders may be packed up, a shorter connecting rod put in, or if the piston has sufficient metal in it a certain amount can be turned off the head, thus increasing the compression space. Engines with too high compression never run smoothly; even though there is no actual knocking, the vibration caused by overcoming the compression is excessive. A cylinder gauge can be used to test the degree of compression—90 lb. is considered a safe limit.

Illustrating a usual source of knock due to oval worn bearing of large end of connecting rod.



Mechanical Causes

We now come to purely mechanical causes of the trouble. The petrol engine, being of the intermittent torque class of motor—that is, the motion is not continuous and rotary as in a turbine or electric motor—requires all moving parts to be as close a working fit as possible, to ensure smooth running. Any undue wear or backlash in the bearings, or any inaccuracy in the alignment between two moving parts, setting up intermittent stresses, will cause the trouble, but it is not generally so marked, or likely to have such serious consequences, as the knock resulting from pre-ignition and faulty timing. It is quite easy for a practised ear to distinguish between the two kinds of knock. An engine with loose bearings may, if need be, be run for a considerable time without anything serious resulting, but it cannot be regarded as good practice to allow the bearings to get into a bad state of wear. These should be taken up or adjusted as soon as it is convenient to do so: this means, of course, when the car can be spared. The true alignment of engine shaft and clutch largely depends on the bearings being in good order. Special attention should be paid to the connecting rod bearings, as there is a greater tendency for these to wear oval, taking, as they do, the direct thrust from the explosion, and with a tendency to wear on one side. Care should be taken to see that the cylinders are firmly screwed down by the flanges to the crankcase.

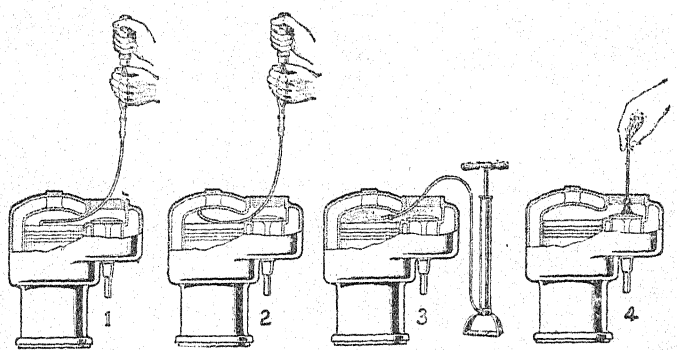
The nuts securing the connecting-rod bearings should always be tight and held by split pins. Any slacking back would result in a bad knock and probable damage.

Knock can be caused by a badly fitting piston. The proper clearance should be 1-1000th in. The lower end of the cylinder may be worn oval or bell-mouthed. The remedy is to have the cylinder bore ground true and a new piston fitted.

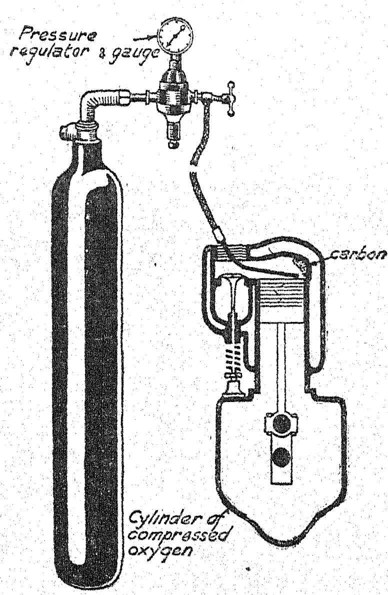
Knock Caused by Insufficient Lubrication

The smooth working of the pistons against the walls of the cylinders obviously depends on there being constant lubrication of the surfaces.

Cylinder Cleaning or Decarbonizing Processes



Hand scraping method with special tool. (1) Cleaning the piston head. (2) Cleaning the combustion chamber. (3) Blowing out the powdered carbon deposit by means of nozzle connected to a tyre pump. (4) Lifting stray particles of carbon by means of a brush inserted through valve port.



Oxygen process. The principle of this is the application of a stream of oxygen gas, regulated to about 15 lb. pressure, on to the heated carbonized surfaces. A taper or spirit torch is first introduced into the cylinder to heat the carbon. On turning on the gas the carbon is volatilized.

Any falling off in quantity, or even quality, of the lubricant may cause either knock or thump, so that this fact should be kept in mind if any trouble of this sort develops. The engine may be in good mechanical condition, yet, running with nearly dry cylinders, a knock would be inevitable.

The Removal of Carbon Deposit

There are a number of methods for effecting this. There is the use of a liquid decarbonizer, which is poured into the combustion chamber. After a time the carbon deposit is softened, and can be blown out of the cylinders after starting up. Another plan, and a very effective one, is to burn out or oxidize the carbon by directing oxygen gas into the heated cylinder. This is a patented system, but the plant for the process is in use at many repair shops. The mechanical methods comprise that of disintegration of the carbon by the use of rapidly revolving cutters or chains placed in the combustion chamber. The powdered carbon can then be blown out by air pressure. Then there is the old time method of using scrapers of various shape. These are introduced into the cylinder by hand after it has been dismantled. This method is a laborious one, but generally effective.

Noises in the Transmission, etc.

The most usual noise which cars develop is that of a humming or grinding nature, and this may be safely attributed to worn gears in the gearbox, unlubricated gears, or the bevel gear in the rear axle requiring adjustment.

Squeaks are of three kinds: the continuous, the regularly intermittent, and the occasional squeak. The first will generally be found to originate in a small bearing, the second at larger surfaces and such parts as universal joints, and the last to come from such details as the springs, lever connections, etc. It is obvious that, in looking for points from which the squeak may arise, the first step is to ascertain if the noise comes from the engine, the clutch operating gear, the transmission or the brakes. If the car be stopped with the gear lever in neutral, and the squeak continues, it of course follows that the cause of the trouble is in the engine, the clutch gear, or the gearbox. In order to eliminate the latter, the clutch pedal may be depressed, when, the clutch being withdrawn, the gear shaft will come to rest. Movement of the clutch pedal up and down should enable it to be determined if the clutch withdrawal collar, etc., is at fault, and if it is not, the remaining possible source of the squeak is the engine. As instances of usually unsuspected causes of squeaking in the engine, it may be mentioned that a drop of oil applied to a valve spring has often stopped the noise, the springs being out of the straight, and so touching the valve stem guide; whilst a squeak noticed upon turning the engine by hand may often be traced to the revolving grip of the starting handle. Should the squeak discontinue when the car is stopped, it is evident that it originates in the transmission gear, wheels, or brakes. The best way is to determine if it is the brakes which are at fault. This is worth while trying before stopping the car. First of all make sure that the brake lever is as far as it will go in the "off" position, then slightly apply the brakes, noting if this has the effect of varying or increasing the noise; if it increases when the brakes are slightly applied, it will be obvious that the source is at this point, and a drop of oil may be put on the drums or the brakes re-adjusted to effect a remedy. If the noise occurs only when the car is reversed, it does not of necessity imply that the reverse pinion of the gear is at fault, and it may often be traced to the above cause, certain forms of brakes, especially those to be found upon cars of early construction, having a tendency to bind upon the drums when the car is run backwards. The

trouble very rarely originates at the wheels; feeling each wheel bearing to note if it is hot will quickly enable it to be determined if the lubrication here is at fault. The universal joints of shaft-driven cars receive, in the majority of cases, far less attention than they should, and in certain designs of propeller shaft especially a squeak may readily arise through neglect of this detail. If this is suspected, the actual source may usually be determined upon removal of the floor boards, and then pushing the car backwards and forwards a foot or two; in the block form of universal joint, a handful of grease pressed

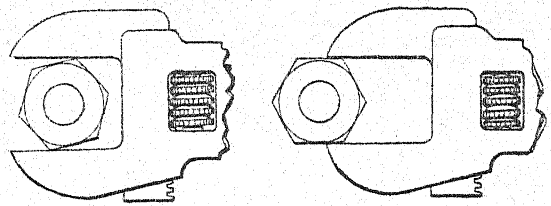


FIG. A. FIG. B.

into the block guides will effect an immediate remedy, or in the case of the pin type a few drops of oil will serve to lubricate the joint. It is in cars of older make that this trouble is most likely to occur, and with the attention which has been paid to the proper lubrication of the universal joints in more modern designs, mysterious squeaks are hardly likely to originate in this portion of the car's mechanism. Intermittent squeaks generally come from the springs, both the shackles and leaves being liable to give notice of friction in this way if not properly attended to. Therefore, some lubricant should be introduced between the leaves occasionally. A small instrument is obtainable from accessory depots for assisting in locating knocks, etc. It acts on the principle of the physician's stethoscope.

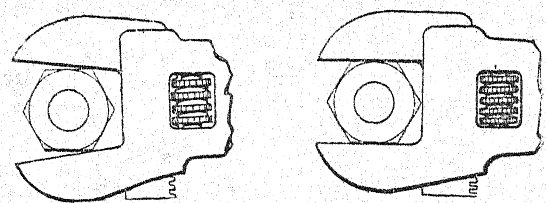


FIG. C. FIG. D.

How to Use the Spanner

To a careful observer of car mechanism in many cases there is indisputable evidence that the owner has not learnt how to properly manipulate the all-useful spanner. It is by far the most necessary and often used of all the tools in the motorist's kit, and yet, perhaps, no other tool is capable of doing so much damage when carelessly handled. This applies more particularly to the adjustable spanner—the standard size box and key spanners do not admit of serious misuse, as these

will practically only fit those nuts they are made for. The fundamental rule for using an adjustable spanner is first to get as tight a grip of the sides of the nut as possible by screwing up the jaw till it will go no further when applied to the nut. When the sharp corners of the nut are found worn away, or burred up, it has undoubtedly been caused by the spanner slipping through not being properly adjusted. This commonest fault is illustrated in Fig. A. The consequence of continued slipping is that the nut soon becomes useless, and cannot be moved till new faces have been made on it. The next fault is that of not placing the spanner far enough on the nut (Fig. B). This also tends to burr up the corners of the nut, and, at the same time, it strains the jaws of the spanner badly, so that, when next applied to a nut, it will not fit the sides accurately, as shown (Fig. C). The spanner properly applied is shown in Fig. D. As a rule novices err on the side of applying far too much force rather than too little in tightening up a nut Of course, it must be made secure, or the consequences may be very serious; but, all the same, it is easy to overdo it, and possibly strip the thread from the bolt or nut. The practised hand never uses a big, long-handled spanner on a small nut if he can avoid it. A big spanner, of course, is a very powerful lever, and with even slight pressure on the handle enormous force is applied on the nut. For small nuts, such as are used on the carburetter, ignition and lighting devices, etc., an ordinary bicycle spanner—a good quality one, with hardened jaws—answers perfectly well. There is a tendency amongst some novices to be continually using a pair of gas pliers for unscrewing small nuts. This is a bad practice, and one to be avoided except in a case of emergency, such as when the spanner is mislaid. Pliers may be used for moving round milled-edge nuts that have got fast, although these are never intended to be screwed up with anything but the fingers.

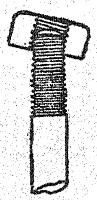


FIG. E.

FIG. F.

Damaged Screw Threads

Whilst dealing with the subject of the tightening up of nuts it is opportune to mention a few of the commoner mishaps that may occur when tightening up nuts and bolts. The first of these is that of a nut becoming cross-threaded, and the finer the pitch of the thread the more liable it is to occur. It is caused by the nut not being started properly, and the nut has got slightly on the skew. This is always known by the fact of a nut that has gone on its bolt easily before suddenly getting tight. No nut should be such a tight fit to its bolt that it cannot be turned once or twice with the fingers to make it engage. Fig. E gives an idea (exaggerated) of a cross-threaded nut. Suppose a nut cannot be made to start on its thread as it should do, it will probably be found that the first thread on the bolt has got burred (Fig. F). This is very likely to occur if the end of the bolt has been struck

with a steel-headed hammer. A piece of brass, soft metal or fibre should always be interposed. This defect can be made right by filing off the burr and clearing the start of the thread with the edge of a smooth half-round file. One of the worst mishaps that can occur is to twist off a bolt at some important part of the car mechanism, such as a holding-down bolt for the engine cylinder. The usual cause of such a breakage is trying to force the nut up against the shoulder or dead end of the thread (Fig. G). A washer or two slipped over the bolt will

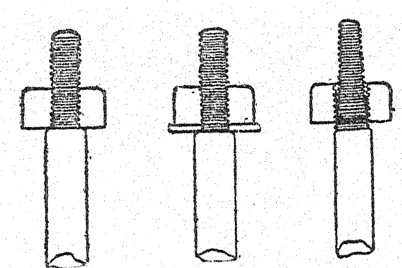
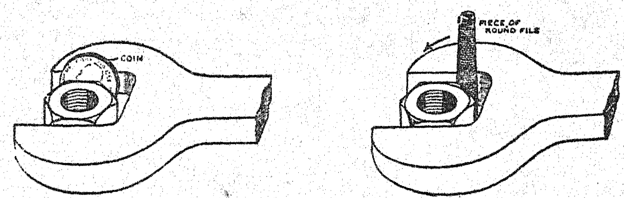


FIG. G. FIG. H. FIG. I.

prevent it (Fig. H). Sometimes a bolt has its thread badly cut; that is to say, it is not of uniform diameter throughout its length, usually widening towards the base (Fig. I). Now, if a nut fits the smaller end well it will jam on the wide end, and if it is forced on further, one of two things will happen—either the nut will split or burst, or (if it is a very strong one) the bolt will twist off. The remedy is to have the thread on the bolt touched up by running the cutting die along it. This is, however, a job for the repairer who has the necessary tools. Occasionally nuts become very tightly fixed on the thread, and, as often happens, the position of the nut is so inaccessible that the task of



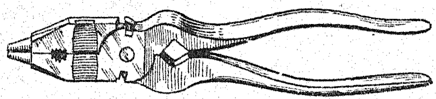
Emergency method of using a spanner which is too large for the nut. A coin may be used as packing, or a short piece of round file inserted. This latter method will serve well in the case of a nut with worn corners.

removal is by no means easy. It is important first of all to see that the spanner has a good hold on the nut, and for inaccessible positions an Auto-clè set of box spanners, with universal joint, is a useful tool. With this arrangement a nut can be got at in most awkward positions. When a good grip of the nut has been obtained, it is equally important to be certain that the effort to turn it is being made in the right direction. Now it is not at all unlikely for one to tighten a nut instead of loosening it by unthinkingly applying the force on the spanner from left to right, instead of from right to left. It is just possible, of course, that the thread might be a left-handed one; but

it is the exception to use left-handed threads in car construction. If the nut fails to move with a reasonable amount of force, examine the thread on the bolt and see if this is burred over slightly at the end. This would account for the trouble.

Application of Paraffin to a Tight Nut

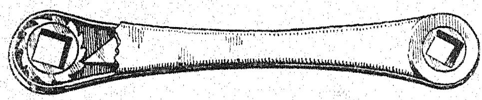
A method worth trying is that of warming up the nut by pouring a little paraffin or petrol over it and lighting it. The result is, in many cases, that the nut expands sufficiently to ease it on the bolt. It is better if, previous to warming the nut, some paraffin is poured over it and left on for some hours, in the hope that some of it may work down the thread. Steady application of the spanner (if necessary a piece of iron tubing can be slipped over the handle to increase the leverage) should suffice to move the most refractory nut. It is important never to use a tight-fitting sparking plug, no tighter than will enable a small spanner to screw it up. If it has to be forced it may prove an extremely difficult matter to unscrew it. A good plan is to rub a little graphite grease on the threads of any new plug when fitting.



Combination pliers, with renewable cutting jaws. Provision is made for gripping nuts, etc.

Treatment of an Immovable Nut

A nut may defy all the usual methods to loosen, such as extra long spanners, application of paraffin oil, heat, chisels, etc. Evidently, in this case the nut has become securely rusted up on the thread, and the only result of extreme force would be to twist the bolt and probably break it off. The proper course is the rather drastic one of splitting the nut on one side, thus springing it open, when it can easily be removed. With an ordinary geared hand drill and a sharp bit a couple or more holes are drilled down from the upper face of the nut and so close together that, by means of a chisel, they can be cut through. Providing one can conveniently manipulate the drill, the operation should not take many minutes to perform. The bolt, of course, is not injured in the process.



Ratchet spanner. Part cut away to show the mechanism.

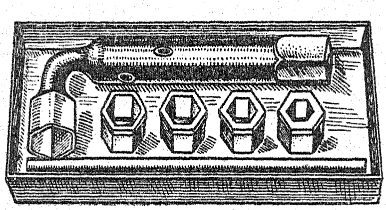
The Use of Lock Nuts and Spring Washers

Owing to the vibration to which the nuts used on the mechanism of a car are subjected, it is usual to provide means to prevent the nuts accidentally slacking back. Neglect of such provision may easily lead to serious trouble or damage resulting. The castle-headed nut is largely adopted, in which there are a number of slits across the upper face of the nut, one of which registers with a hole in the bolt, and through which a split pin is passed, the ends of the pin being then opened out. Spring washers are less effective, but answer well enough for the less vital parts of the mechanism. There are, however, several forms of spring locking washers which hold the nut positively, and these are

quite safe for any position. Where none of these devices are available, a loose nut can be rendered secure by screwing another nut on top of it if the thread is long enough. If not, a smart tap from a centre punch on the last thread of the bolt will burr the thread and keep the nut on.

Special Types of Spanners

There are numerous designs of this tool made with a view to facilitating unscrewing and screwing up of nuts. One of the most convenient is the ratchet spanner, which acts by a ratchet or back and fro motion without having to lift the spanner from the nut for each movement. It is of the box type and not adjustable, so that a set must be kept to suit various sizes of nuts. Of the adjustable type of spanner there are many which give a quick adjustment on to the nut. Of the box type of spanner the variety is also a large one, and there are others made on the principle of a pair of pliers with serrated jaws, but designed to exert extra grip and leverage. For small nuts these tools are very handy and save time.



Useful set of box spanners which all fit in the same holder and thus economize space in the tool outfit.

Testing Wheel Alignment

Relative to the expense of tyre upkeep, it has been shown that a good deal of unnecessary wear and tear results from faulty alignment of the wheels. In some instances the life of the tyres has been shortened by one half of the normal running life, and this, of course, is a pretty serious matter. In the tyre makers' instruction booklets this matter of alignment is invariably mentioned. Readers are told to "see that the alignment is correct," but the information stops short at this, and the really important part is omitted. When a car leaves the factory the alignment of the wheels is, or is supposed to be, exactly right. The influences of hard work on the road and general wear and tear are always tending to impair the accuracy of the original alignment, so that it is safe to say that it rarely remains mathematically correct after the car has had its first run. But this is not what causes the trouble with the tyres. It is the minor mishaps and "general banging about" to which the average car is subjected. For example, it is difficult to avoid at some time or other striking a very bad stretch of road with deep holes or gutters on its surface. In the daytime a careful driver would watch carefully for the holes and inequalities, and, if he had to go over them at all, would slow down as much as possible. At night time it is difficult to avoid a bad hole, and one or other of the axles is slightly strained and the alignment disturbed. Some axles, of course, are stronger than others, but to make an axle proof against every conceivable contingency would in many cases necessitate piling up the weight more than is desirable in the case of light and medium-powered cars. The axle proper may be slightly strained out of truth by a severe shock, or a collision may affect the steering axles on which the wheels pivot. Striking a kerb obliquely when stopping is not an unusual cause of one of the steering axles being strained, and the damage is rarely suspected at the time.

Bad cases of faulty alignment and strained axles can be seen every day. It does not need a mechanically-trained eye to detect them. These cars have a "gone at the knees" appearance, which is unmistakable. The steering wheels, when looked at end on, seem to be making for the side streets instead of going straight ahead. A strained back axle and one wheel running much out of lateral truth is a not uncommon spectacle.

There are many people who own cars who no doubt have been not a little surprised to find that the front wheels do not stand straight up,

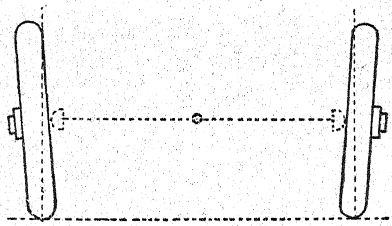


FIG. 1.

but are tilted appreciably. Note Fig. 1. The wheels are canted inwards at the point of contact with the road. This is done purposely by slightly canting the axles on which the wheels pivot—not the axle proper. One reason is this: the spokes of the wheel are not set dead straight between the hub and the rim. By slanting them a little, the wheel is made stronger and can resist any blows in a sideways direction better than when the spokes are set straight. But it has to be borne in mind that

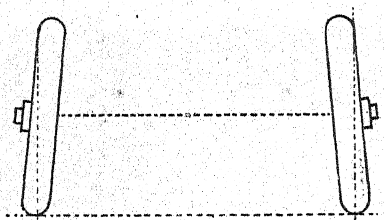


FIG. 2.

the weight of the car is supported on one spoke at a time, and it stands to reason that the weight will not be properly supported by a slanting spoke. The spokes are therefore brought into an upright position by the simple expedient of setting the wheel a few degrees out of the vertical. Another reason is that the steering centre line is brought into coincidence with the line of tyre contact with the road. This makes the steering easier. On some cars the pivot is set inside the hub centre. To prove if each wheel is inclined the same amount, the exact middle of the axle should be found by measurement. If a plumb bob is dropped from this point, and a mark made on the ground, the distance to each inner edge of the wheel should be exactly the same. To make this test the car should stand on a good surface, with the tyres pumped

equally and very hard. The front wheels should be set straight in line with the rear ones. It has to be assumed also that the wheels run true laterally. Fig. 2 is that of a bad case of deflected steering axle such as might be caused by the wheels striking a rut at high speed. This would easily be apparent without making measurements. Fig. 3 shows one wheel deflected and the other correct; in this case the wheels are supposed to be set quite vertically. By the plumb bob test aforementioned, the distance B to A would be greater than C to A. In a bad case B to A might be from 1 to 2 inches greater than C to A (Fig. 3). This test is all right in so far as a vertical direction is concerned, but the wheels have to be always "parallel

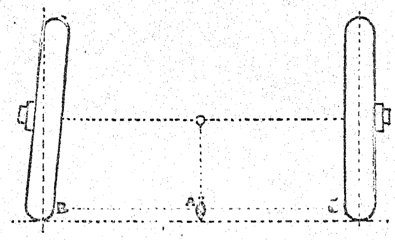
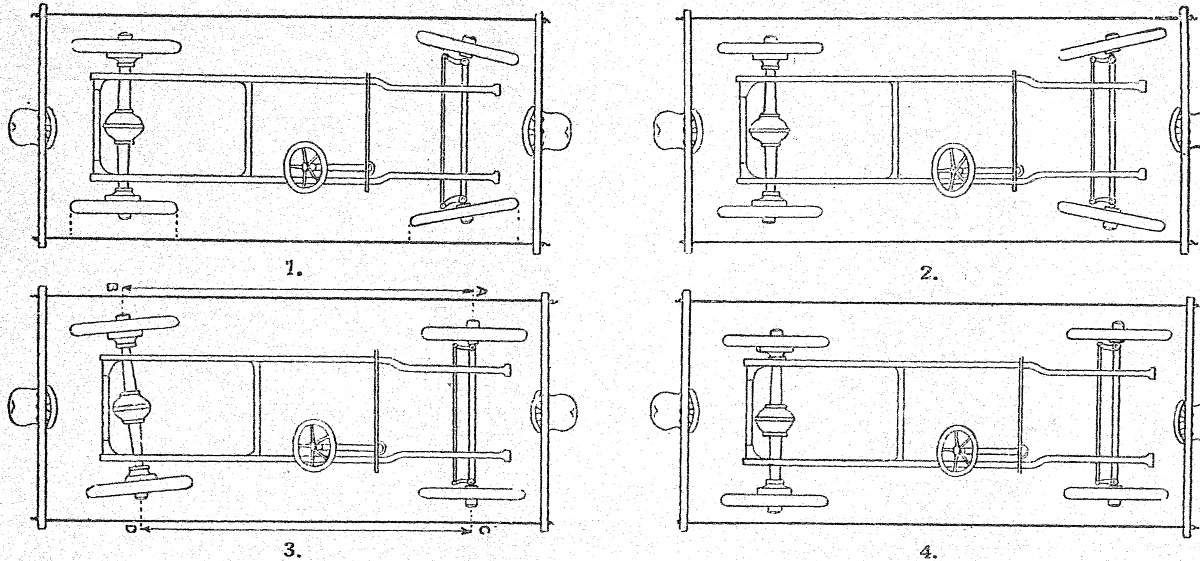


FIG. 3.

in plan," that is to say, if you are looking down on the wheels from above when these are set to steer straight ahead the appearance should be like Fig. 4, page 196. If they are like Fig. 5, page 196, the wheels are badly set.

The Straight Edge Test

If the wheels are quite parallel, as shown in plan, the distances from A to B and from C to D must be equal. These measurements can easily be made with a long strip of wood or straight edge, or even a stretched piece of string. It may be that in some instances this want of parallelism is due to the steering link or crossbar being too short; or, if adjustable, it has not been set correctly to bring the wheels quite parallel. In cases where the wheels are built up with straight spokes or wire no canting may have been given, the wheels standing quite vertical. The same tests for vertical parallelism and also in plan can be applied. There is another fault which may arise: the front and rear wheels may not track with each other. On chain-driven cars an arrangement is always provided to adjust the tension of the chains equally by means of an adjustable stay or bar at the ends of the axle. Unless considerable care is taken when adjusting these stays, the axle may not be truly at right angles to the frame of the car. This will be very bad for the tyres, and also for the chains and chain sprockets. Here again the alignment test can be applied, a long straight edge being laid across the outside face of the front and rear wheels. If both sets of wheels are in track, the straight edge (or stretched cord) will just touch equally at the four positions. In a case where the steering wheels are canted, the test should be made rather low down. The same fault would be indicated by the car leaving two distinct sets of tracks behind it when running on a wet road. It will be obvious that the front wheels make one track and the rear wheels another. A fairly common remark made is that a certain set of wheels "do not run true." This defect should not be confused with the previously mentioned ones, which mainly concern the setting of the axles. But, nevertheless, wheels out of truth will have a bad effect on the tyres, as the tread is worn unequally. A wood or wire-spoked wheel may become out of truth laterally as the result



Illustrating the principles of testing alignment of wheels by the simple parallelogram method in which two cords are tightly stretched between two bars of wood drilled at exactly similar positions and set square across supports (two chairs can be used in an emergency). (1) Front wheels set inwards and much out of line with rear wheels. (2) Front wheels set outwards. (3) Rear axle much out of square. The measurements AB and CD will be dissimilar. (4) Shows the rear axle set over to one side and the rear wheels thrown out of track with the front ones. If the wheels are in line and parallel with each other the distance between the wheels and the cords will be equal, the car, of course, being set exactly central. The divergencies from correct setting are shown exaggerated for clearness.

of a blow or similar accident, and it is a defect easily noted by spinning the wheel round. A piece of chalk held close to the edge of the rim whilst it is spinning will rub at some points and not at others. This test should not be made on the side of the tyres, but on the rim, because tyres are not always moulded dead true, may not have been adjusted to the rims quite accurately, or a detachable non-skid may have been fitted, and these often result in a slightly "wobbly" appearance, although the wheel may be quite true. A wheel may also be out of truth circumferentially, but rarely so except as the result of very bad workmanship in building the wheel. In cases where faulty alignment of the wheels is the result of strained axles the remedy must be effected at the repair shop, as the parts have to be taken off and trued up by means of special appliances. In some instances the parts have to be heated.

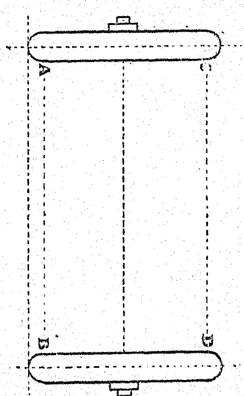


FIG. 4.

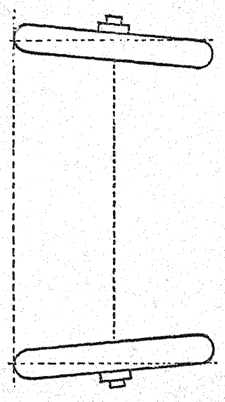


FIG. 5.

Remedies for Explosions in the Silencer

A car that is addicted to exhaust-box explosions is a trial to its owner and a nuisance and danger to the public, and it is worth going to a good deal of trouble to cure it. The main cause of it is explainable in simple terms: unfired charges from the engine collect in the exhaust-box, and if a slow-burning charge in one of the cylinders follows the ejection of the former, it is bound to explode them. In this as in the case of backfiring along the induction pipe, it is the gas which is the principal factor contributing to the trouble. If, when on the road, a car suddenly develops the defect of persistent banging in the exhaust box, and loss of power, which will follow as a matter of course, it will be safe to deduce that there is something wrong with the carburetter or the petrol supply, a stoppage in the jet or petrol pipe, or the tank running short of spirit are almost invariably indicated by exhaust-box explosions. These explosions may vary in intensity a good deal; it depends largely on the type of exhaust box fitted: the more resistance offered to the exploded charges the louder the report; it may, in fact, easily happen that the ends of the exhaust box may be blown out. A good idea, which, however, is rarely put into practice, is to fit a safety valve which will open under any undue internal pressure. Many an exhaust box would thereby be saved from destruction

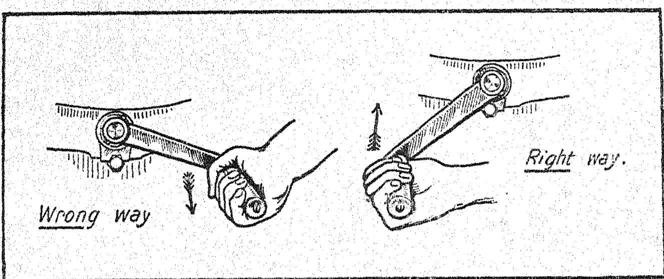
Another, but more obvious, reason why these explosions sometimes occur is switching off and on with the throttle open, a practice some motorists adopt when descending hills, through having no provision for throwing an air port open so that the cylinders can draw in air instead of mixture for compressing to obtain engine brake effect. When switching on again there is always the risk present that the exhaust box, full of mixture, will go off, especially so if the spark is retarded, because then the charge will still be in process of combustion when it is ejected through the exhaust valve.

Test for Efficient Carburation

Many car owners appear to overlook the fact that running the engine light and noting the nature of the exhaust gives one a reliable general indication of whether the carburation is good or bad. A practically odourless and colourless—or, rather, a smokeless—exhaust is a good indication. There is no mistaking the somewhat pungent odour of an over-rich mixture exhaust, whilst an excessively over-rich mixture produces a "black" exhaust, which might be fairly compared to the smoke from a paraffin lamp turned too high. But it must be remembered that even a perfect mixture and high-grade petrol will not give an actual odourless exhaust; there is certain to be a slight characteristic smell, not easy to describe, but this does not come from unburnt petrol. Using a sheet of clean, white paper as a background, a "clean" exhaust should show but the faintest of a brown tinge. Of course, in making such a test, it is to be assumed that the lubrication of the engine is normal, and that no vaporized oil, with its resulting smoke, is coming through with the exhaust.

How to Grip the Starting Handle

Many mishaps, such as a sprained or even fractured wrist, have occurred when starting up the engine because the handle has been gripped the wrong way. In the event of a back-fire jerking the handle backwards, it will automatically free itself if held in the right way. It



should be given an upward pull and not a downward push. The fingers must embrace the handle rather loosely, as shown, so that no resistance is offered if it jerks back, which usually results if the ignition is too much advanced. If the handle be gripped in the wrong way, as shown, it is obvious that the wrist must suffer in the event of a back-fire.

HINTS IN BRIEF

The collection of rain-drops on a glass windscreen which obscures the view of the driver can be prevented by rubbing the weather side of the glass with a piece of clean rag moistened with glycerine.

Leather upholstery that has become stained and shabby can be much improved by treating with one of the various leather revivers sold in a number of colours

A Cape hood which is no longer waterproof and has become soiled can be restored as new by careful painting with a special waterproof varnish sold for the purpose.

Holes in the fabric of a Cape hood should be neatly patched with pieces of the same material sewn or cemented on from the inside.

Two very useful preparations are Chatterton's compound and Seccotine. With these any repair requiring the aid of a strong adhesive may be effected. Chatterton's compound is used in the manner of sealing wax. It is an excellent insulator for electric-light or ignition wires.

Water which comes from a chalky district should preferably not be used in the water-circulation system, because this results in deposits of lime forming in the pipes and radiator. Distilled water costs about 3d. per gallon only, and can be obtained through any large chemist or druggist. Failing distilled water, well-filtered rain-water should be used.

The standard anti-freezing mixture for use in the circulation system in winter time is: One part best quality glycerine, three parts water. Loss by evaporation should be made up by adding water only. In exceptionally frosty periods the proportion of glycerine should be slightly increased. An extra precaution is to cover the radiator with a heavy rug or sacking when the car is garaged or standing in the open.

Iron cement is useful for sealing a crack in a cylinder water-jacket or any other metal part not necessitating a welded repair. Leading accessory concerns supply it.

Brasswork that has been polished and has to be left for any length of time, especially in a damp place, should be well vaselined. This also applies to iron or steel work. There are, however, anti-rust preparations sold.

The threads of sparking plugs, valve port caps, and exhaust pipe connections should occasionally be brushed over with some powdered graphite. This prevents seizing or binding of the threads from the oxidizing action of the hot gases.

The exhaust pipe and silencer generally tend to become rusty. There are a number of ways by which this can be minimized. The simplest is to well brush the surfaces with blacklead at intervals, after clearing off any mud, etc. A more permanent protection is obtained by using galvanizing paint.

A sparking plug should not be so tight a fit in the cylinder that it cannot be screwed in with the fingers for at least two-thirds of the thread. Otherwise there is risk of a cross-thread or badly-cut thread jamming tight.

To test the firing of the cylinders independently, the magneto cables should not be disconnected, as this throws a severe strain on the insulation of the armature of the magneto. The proper way is to have a short-circuiting switch or cut-out fitted to each plug.

The sparking plug terminals, or the magneto terminals, unless of the insulated pattern, should not be touched whilst the engine is running, as this results in a severe shock being received by the operator. As a precaution against this, the plugs can be fitted with anti-shock connectors.

It always saves time in investigating for causes of misfiring to try the effect of a new set of plugs, because, in the majority of cases nowadays, any persistent misfiring is due to a sparking-plug defect.

The standard width of the sparking-plug gap is half a millimetre or 1-50th in. A wider gap than this may cause difficulty in starting up.

The best surface on valves and valve seats is produced by the use of a proper tool, known as a valve-seat cutter. When valves are ground in in the usual manner a finish should be given with either crocus powder and oil or fine glass powder and oil.

If exhaust valves require grinding in more than once in 1500 miles, it proves that something is at fault. It may be too rich a mixture, a choked silencer, valve lift diminished, or ignition timing retarded.

After, say, 6000 miles running, the valves, more particularly the exhaust valves, should be tested between lathe centres and set true. More or less distortion of the valves takes place after continued use. If the stems are worn thin at the top or show badly-scaled parts, it is safer to replace them by new valves.

If the valves, owing to many seasons hard work and frequent grinding in, have sunk down into the seating, it is advisable to have the seating recut and a new and slightly larger set of valves turned to suit, otherwise considerable throttling of the gases will occur.

Squeaks from exhaust valves may generally be stopped by dropping a small quantity of powdered graphite down the guides.

If the valve tappets are noisy, a great improvement can be effected by having steel caps with fibre insets fitted. The smallest amount of clearance between the stem and tappet should be allowed.

Noise from the valves is accentuated if the springs used are of unnecessary strength. In many instances weaker springs may be advantageously used.

Summary of Defects that may Occur in Running and What they may Arise from

Engine stops.—If suddenly, may be due to failure of the spark—Ignition circuit disconnected—Broken wire—Magneto defect—Terminal loose—Wire broken under the rubber insulation.

Gradual stoppage, with misfiring.—Petrol all used up—Carburetter choked with grit at the jet or gauze filter—In pressure-fed cars the pressure pipe may be leaking at one of the unions, or be choked up with carbon—Petrol tank air bound—Petrol supply tap may have partly closed—Sparking plugs fouling through over-lubrication—Petrol pipe sprung a leak, or union come unscrewed—Platinum contacts of magneto require cleaning.

Loss of power, engine fires regularly, but is weak.—Loss of compression at valves or plugs, sometimes at the piston rings (but not a usual fault)—Mixture too rich in petrol, due to flooding carburetter—Engine not getting enough lubrication—Spring on inlet valve weak—Lift of exhaust valve reduced—Silencer outlet choked with mud or charred oil—Valve tappet clearance too small or too great.

Loss of power, engine firing irregularly.—Defective connection at some part of circuit—Partial short-circuit—Insulation of high-tension cables damaged, and spark jumping to "frame"—Moisture on plugs—Damp in the magneto distributor—High-tension terminals on magneto loose or damaged—Sparking plug cracked or insulation broken down—One or more cylinders misfiring.

Overheating, as indicated by water in radiator boiling—Defective circulation—pump out of order—Supply pipes or radiator tubes partly choked with fur (lime)—Steam lock in pipes—Inside of one of rubber joints fouling bore of pipe—Driving too long on low gear—Fan stopped working (belt broken or slipping)—Mixture too rich in petrol—Using excess of gas—Spark retarded—Exhaust throttled—Timing of valves incorrect—Silencer choked up.

Engine runs well, but car drags.—Clutch slipping—Oil on leather—Spring wants tensioning—Leather worn and wants renewing—If a metal plate clutch, springs at fault or plates worn—Brakes partly on.

Knocking in engine.—Pistons and cylinders require cleaning free from carbon deposit—Lubrication defective (a bearing may have "run")—Ignition too far advanced—Self ignition due to fouled plugs or overheating—Loose or worn bearings—Gudgeon pin loose—Badly fitting piston—Cylinder loose on crankcase through nuts slacking off.

Abnormal noise from transmission gear (other than due to unskilful changing of the gears).—Want of lubrication of gears in change-gear box or bevel drive on back axle—Pinions damaged—Teeth broken or worn down—Nut loose in gearbox and fouling gears—Clutch drum or flywheel loose—Universal joints on transmission shaft badly worn or damaged—Bearings in gearbox worn, allowing shafts to rock about—Sliding member of clutch out of alignment with cone (sets up harsh grating noise)—Wear of jaws of positive clutch in gearbox.

Hissing sound from engine.—Sparking plug broken or worked loose—Joint between engine and exhaust pipe loose—Union of exhaust jacket pipe to carburetter worked loose—Exhaust pipe cracked—Compression tap left open—Broken piston rings—Crack in piston.

Squeaks and similar noises.—Fork actuating clutch wants lubricating—One or more bearings overheating and want of lubrication—One or more of the brakes partly on—Bearings of spring shackles want lubricating (on some cars the spring ends work in a slide, which requires occasionally lubricating)—Valve stems running dry in the guides.

Engine refuses to start.—Ignition out of order—No spark—Very poor compression—Mixture too weak—Air inlet at carburetter wants partly closing—Leakage of air past inlet valve stems—Plug defective—Water in the petrol—Water in the cylinder due to leak between jacket and cylinder (sometimes occurs in engines with separate heads, or where a screw plug is fitted between jacket and cylinder)—Petrol or other fuel of too high a density.

Explosions in the silencer.—Mixture too weak to fire, or mixture right but sparking wrong—One cylinder missing fire and pumping explosive charges into silencer, which ignites from the heat of the next exhausted charge—Petrol supply failing—Choked jet in carburetter.

Engine continues firing when switched off.—Carbon on sparking-plug points or piston heads—Badly-designed plug, the points of which become incandescent.

Engine very difficult to pull round for starting, or refuses to move at all.—Engine may be "in gear." See gear lever is in

neutral position. (This is very important.)—One or more pistons have seized, due to failure of lubrication, or use of inferior oil—Injection of paraffin into cylinder may remedy it—A bearing may have seized.

Exhaust pipe becomes red-hot.—Running too long on low gear—Using too much gas—Driving with spark retarded—Exhaust throttled, insufficient lift of valve, or choked silencer—Over-rich carburation—Exhaust pipe too small in diameter.

Lubricator stops working.—On the older type of cars the pressure pipe from exhaust may be choked up with carbon—Cover of lubricator leaking—Feed nipples choked—Pump of mechanical lubricator broken down.

Explosions in carburetter or inlet pipe.—Inlet valve not closing properly—Spring defective—Valves overheated—Mixture too weak—Valve timing incorrect—Inlet and exhaust timing overlapping—Ignition retarded too far.

Crankcase becomes very hot and engine weak.—Serious leak of exploded gas past piston rings—Rings worn or broken—Crack in head of piston—Gudgeon-pin loose in piston and allowing gas to escape along bearing.

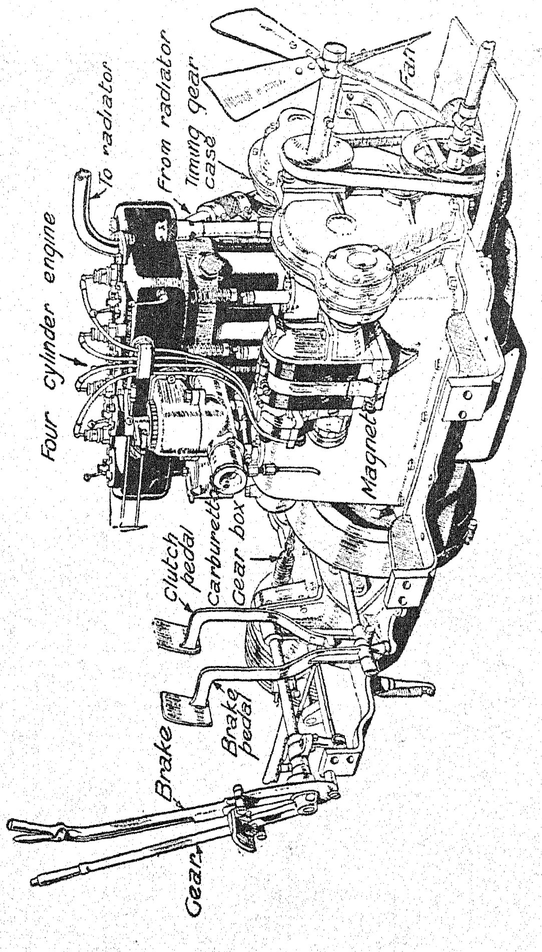
Oil on clutch leather.—Leak from gearbox along shaft—Too much oil in box—Leak from engine into underscreen.

Oil on valves and sparking-plugs.—Excessive lubrication of engine—Cylinder bore worn oval—Piston rings a loose fit—Running engine downhill with throttle shut (oil is then sucked on to top of piston).

Petrol fails to reach the carburetter.—Gauze strainer in base of carburetter choked—Obstruction in the supply pipe—Air lock at a bend in supply pipe—Pressure leakage from tank, or if a gravity tank it may be air-bound—Floating obstruction in petrol tank covering the petrol outlet—Petrol pipe near exhaust pipe causing a vapour lock—Petrol pipe connection nut worked loose.

Continual emission of smoke from silencer.—Engine being over-lubricated, readjust lubricator to give a slower rate of oil flow—The emission of black smoke indicates that the carburation is too rich.

Crack in cylinder.—Water in combustion chamber or in crank chamber indicated by air bubbling through radiator on pulling engine over compression.



An example of a complete four-cylinder power unit with clutch, gearbox, control levers, &c. Ready for mounting in the frame, and connecting up by a transmission shaft to the back axle.

CHAPTER XIII

Private Owner's Garage or Motor-house

Neither a stable nor coach-house is, in one instance out of a thousand, exactly suitable for a motor-house, and alterations are always necessary, although it might happen that in occasional cases those alterations need only be slight in their character. The coach-house is invariably much too small to be used as a motor-house, because no work is ever needed to be done to a carriage there. Washing and cleaning all take place in the yard, and then, when it is put away, a small, unlighted place is all-sufficient for storing the vehicle. The stable is seldom arranged so that, when cleared of its stalls and its fittings, it could be used to keep a car in. One reason is that the doorways are seldom, if ever, wide enough.

When a motorcar is to be housed, ample room is required in a properly paved, well-lighted structure with wide doors, a pit, cupboards for accessories and sundries, a working bench, and other suitable equipment. If the stable and coach-house adjoin, the removal of the partition between them may give the requisite accommodation, and where one car is kept the following are the minimum dimensions:—Length, 18ft.; width, 10ft.; height, 9ft. It would be preferable to have a length of 25ft., a width of 12ft., and a height of 10ft.; whilst, if two cars be kept, it is better to place them side by side in a house not less than 20ft. wide.

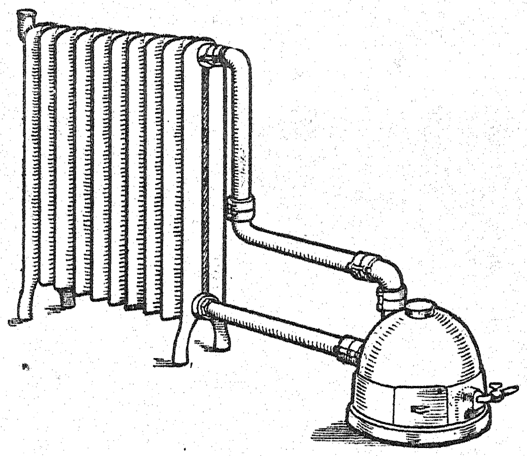
An Inspection Pit Useful, but Not a Necessity

The need for a pit is much less nowadays than it used to be in the early days of motorcars; but although it may only be needed for the purpose of giving comfortable working access to some part of the mechanism about three or four times a year, when it is wanted it is usually wanted very badly. The depth need not be so great as it is usually made. A convenient size is to make it 9 ft. long, 2 ft. deep and 2 ft. 6 ins. wide. Pits can now be obtained made in galvanized iron to any required dimensions. This plan avoids the expense of a brick or concrete lining to the pit, and it is easy to keep clean. A portable seat should be kept in the pit, and this can be moved to a comfortable position and the worker can be seated.

Large drip-pans running on small wheels should be placed under each car to catch drops of oil and thus protect the floor of the house and prevent oil being transferred to the tyres.

It is absolutely essential that ample top light should be provided. This is very seldom the case with either a stable or a coach-house, and where conversion takes place large roof-lights should be put in, otherwise there is constant trouble to anyone working on the mechanism. The glass employed in roof-lights should be rough-rolled, so that direct sun-rays cannot pass through. It is also essential that the bench should be placed in a good light, a north light running the whole length of the bench being the best scheme. Wherever possible

electric light with a few wall-plugs should be installed. A wall-plug in each side of the pit proves a convenience, as it saves a wire running across the floor to the underside of a car. Wire in such a position is sure to trip one up in a hurried excursion from the pit in search of some required tool or part.



Hot water heating apparatus for motor-house. The small boiler is heated by gas, and is fixed in an iron box outside the motor-house. (The chimney fitting on top of the boiler is not shown).

To be able to move a car about conveniently in the motor-house a device known as a "skate" fixed under each wheel is useful. This device works on castors and makes an efficient substitute for a turntable.

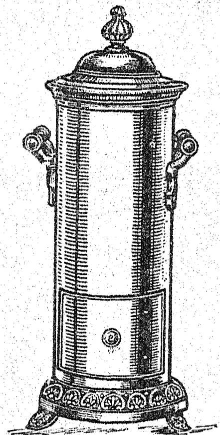
Sliding doors may sometimes be introduced with advantage, and in any case, except where the building is of very large dimensions, a doorway for each car should be provided. Ample cupboard and shelf room is indispensable. One large cupboard, with suitably-arranged racks for tyres and air tubes, should be fitted up. It should be made quite dark, under which condition rubber is best kept.

The racks should be arranged out of curved pieces of wood, so that tyres and tubes (which latter should be kept partly inflated) can be supported upon them, for, say, 2 ft. of their circumference.

The Warming of a Motor-house

This is always a problem, but it must be faced. In the case of a doctor's car, for instance, it is not permissible to empty the radiator every night as a precaution against frost. Refilling might mean a fatal delay. The best method is, perhaps, a hot-water system supplied from a boiler over an outdoor stove, such as is employed for greenhouse work; but this means stoking unless gas be used. An electric radiator which could be switched on from the house would be an excellent device, as the effects of a sudden and unexpected frost could be checked without, maybe, someone turning out in the night air. Another reason for keeping the motor-house warm and dry is that tools will get into a

very rusty state if damp can get at them at all, whilst lamps and bright parts tarnish quickly, thus creating much unnecessary and unprofitable work. Suitable slow-combustion stoves using a solid



Slow-combustion stove for garage or private motor-house use. It is charged with a special fuel which burns for many hours without attention. It keeps the atmosphere dry and warm and prevents freezing up of the water circulation system and rusting of metal work.

prepared fuel, the safety of which is favourably spoken of by users, are now readily obtainable from accessory dealers. These form the cheapest and most convenient means of heating a motor-house. Washing space with proper drainage and concrete or brick surface should be arranged if it does not already exist, and it is better for this to be under cover if possible. A simple glass roof can perhaps be arranged over the washing yard, when this operation can be done in comfort and regardless of weather. A stand-pipe equipped with hose is necessary, not only for washing, but for filling the radiator. Precautions should be adopted when washing down in order that petrol may not be carried down into the drains. Waste petrol or paraffin is best disposed of by pouring it over loose earth or gravel in any out-of-the-way place, but not over a garden plot or lawn.

Precautions against Fire

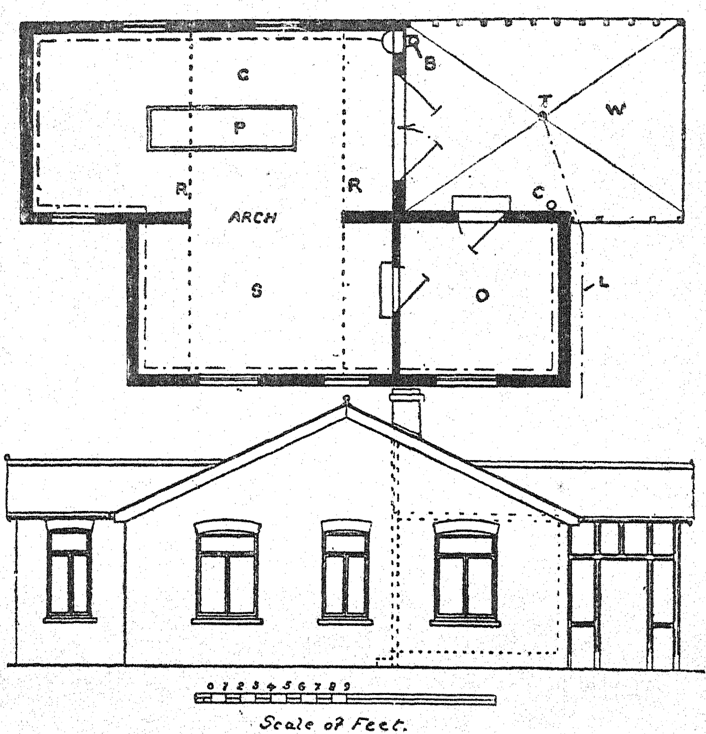
One or more small patent chemical fire extinguishers should be kept in a handy position in the unlucky event of a petrol fire occurring. These are very effective as they generate carbon dioxide gas, which soon quenches a petrol flame, whereas water does not.

A quantity of sand kept convenient to smother a fire is the next best plan to a chemical extinguisher.

Construction of a Motor-house

It is much the more satisfactory plan to have a motor-house built if ground space is available. The important factors in planning out the construction are the overall dimensions of the car or cars to be housed. It is advisable to obtain the exact overall dimensions from makers; these are, however, usually given in the catalogue. Space must be allowed at ends and sides of car of not less than 3 ft. 6 ins., preferably 4 ft. 6 ins. Where several cars are housed, about 3 ft. between each should be allowed. The doors should be sliding or hinged outwards, and high enough to pass car in easily with hood up; an allowance of 9 ft. should be ample.

General Plan of a Private Garage and Workshop

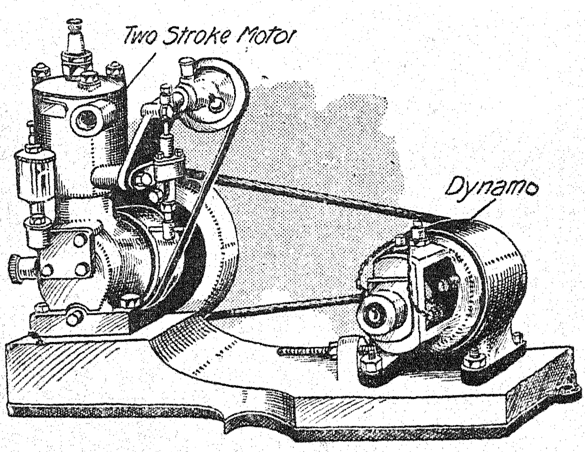


Index to reference letters: G, garage; P, pit; R, overhead crane runways; S, workshop; O, office; W, washing yard. The heating is effected by a greenhouse boiler at B. and piping (as shown by broken line following outline of building). The washing yard has either a cemented surface, or is laid with stone setts. A "fall" is given from each corner, as indicated by diagonal lines meeting at the grating T. Broken lines at L indicate a suitable direction for laying pipes to the surface drain.

A cement floor, although generally adopted, is not the best, as it absorbs oil and becomes unsightly. "Granolithic," or stone flags make the best flooring. The walls should be faced to 4 ft. up with glazed bricks, and air gratings should be fitted just above the floor. Angles should all be rounded to help towards cleanliness. Drains should be open half-round channels. Lighting is best done by skylights and windows, although if a pit is arranged for, a long bow-window, quite near the floor, is very desirable, as a skylight, in this case, would be screened. Water should be laid on, and shelves and cupboard space provided for.

Improvements in Motor House Design

As the result of experience, various practical improvements are continually being introduced in the design and equipment of motor-houses and garages, and for this reason it is advisable for a car owner going to the expense of a private motor-house to obtain the assistance of an architect who has the necessary experience to be able to plan the motor-house to the best advantage and economy of space. The necessity for the place being dry will be obvious, and a proper damp-proof foundation may have to be laid down, and this requires that a careful investigation of the site will have to be made. Where accommodation is limited, it is necessary to give proper consideration to the facilities for getting the car in and out of the motor-house and turning round. There are also many labour-saving devices which might be introduced, and the question of convenient storage of material to be considered.



A simple motor-house or garage electric lighting set, consisting of a low-voltage dynamo driven by a two-stroke motor. This is intended to charge a battery of accumulators, but can also run the lamps direct if necessary.

Electric Lighting Installation

Artificial lighting is best effected by electricity, by reason of its safety and convenience. Even when no current supply mains are available, it may pay to put in a small low-voltage plant, with small battery of

accumulators. An inexpensive combined 1 h.p. paraffin engine and dynamo, giving about 40 volts, would charge the cells, and the installation could be of 25-volt metallic filament lamps. House lighting can be done from the same supply. In this case the cells would have to be of larger capacity. The engine would be equally useful for driving a lathe or other tools in the motor-house. An alternative is to use a special garage paraffin lamp, with gauze protection, or enclosed incandescent gas. A petrol store, of fireproof materials and well ventilated, should be arranged for at a distance about 20 ft. away from the motor-house. An excellent plan is to have a shallow pit built and concreted just below the ground surface, and provided with well-fitting hinged iron covers. Galvanized iron receptacles are now made for the purpose.

Storing a Car in Winter-time

Firstly, the car should be thoroughly cleaned by means of a free play of the hose. Careful soaking off of the mud from the corners will be requisite here, and if, when the cleaning has been done and the surplus moisture removed, a brushing over with paraffin is given, it will be beneficial. This refers to the under parts of frame and machinery, and when thoroughly clean all such parts should be thickly coated with vaseline, this being more particularly important in places where the paint has been worn away in parts, or where there is no covering paint on the metal at all. The treatment with vaseline should be thorough and not scant, and the painted parts should receive attention quite as much as the unpainted ones, because, although the paint is intended to, and does, prevent the contact of the atmosphere with the metal, if moisture is allowed to collect, and remain untouched, it will frequently eat through the covering and attack the metal below, not only causing the paint to chip and peel off, but revealing, then, the parts beneath deeply coated with a layer of rust.

Treatment of Bright Metal Work

The same treatment should be applied to all working parts, which should first be thoroughly cleaned from all old oil and the grit and dirt which it contains. Paraffin is best for this work, to be followed by a very thorough coating with the vaseline brush. And care should be taken that the vaseline is forced into all interstices, into corners around nuts and other such-like places where moisture can collect and cause rust. All metal parts outside the car should be treated in a similar manner. Plated or polished brass fittings, not omitting aluminium, should be first thoroughly cleaned and polished, and then treated with the rust preventer. A permanent protection for bright metal work is to treat it with transparent lacquer. This is easily applied by a brush. It saves cleaning, and if required to be removed this can be done with methylated spirit. Those parts of the chassis which form the outside of the car and are painted to correspond to the finish of the body, such as frame members, springs, tyre rims, bonnet, radiator, the metal fittings on the dashboard, the metal mudguards, etc., should all be gone over with vaseline. The water should be drawn off from the entire circulation system, care being taken to see that this has been thoroughly done and that none remains anywhere in the pipes, connections, or radiator tubes, or serious trouble may ensue when any frost comes along. When once the car has been put into the place it is intended to occupy for the winter, it is most important that it should not be allowed to rest upon its tyres, but all four wheels should be jacked up and supports placed underneath the axles which will carry the car with the wheels just free of the ground. A special type of jack which raises the four wheels simultaneously is now obtainable for this purpose.

The Appearance of a Car: Best Method of Cleaning

If the permanent polish of the paintwork is to be seriously considered, a car should *not* be used on the road for a month after it is finished, and during that time it should be several times washed down with cold water and dried off with a cloth. Upon no car, especially upon a new car, should mud be allowed to set. The car ought to be washed down directly it comes in, without giving the mud a chance to dry.

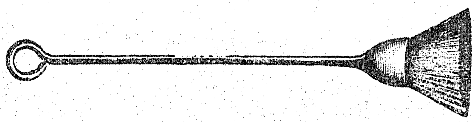
Upon no account should dirt, dust, or mud be *brushed* off. It must be, in the fullest sense of the term, *washed* off. If you have a hose, it will be very useful in getting the mud off the under parts of the car; indeed, for dealing with this portion of the vehicle a hose becomes almost indispensable, if the mud is not to remain and gather, more or less permanently, there.

In using the hose for the outside of the car—that is, for the wheels and bodywork generally—care is essential. In the first place, caution must be used that the water goes nowhere but where it is intended to, and is not splashed wildly about in every direction, both inside and outside the car. Whilst a strong pressure of water from the nozzle is of considerable advantage in cleaning the underparts of the car, where the mud is usually heaviest, and in cleaning the underside of the mud-guards, it is a disadvantage when dealing with the paintwork, because, if a strong pressure is used, it is quite as likely as not, in removing the gritty particles, to force them over the surface of the paintwork so forcibly as to scratch it. If it is possible to reduce the pressure in any way it will be advisable to do so. Apply the water with little force but in plenty. If this is done when a car comes in wet the mud will very speedily and easily be removed.

The Removal of Dried Mud

If the mud has been allowed to dry, then no attempt must be made to get it off in a hurry. The water must be rather poured over it so as to thoroughly soften it and allow it to gradually be carried away as the water runs over it. If you have no hose, then the same principle must be observed. Plenty of water must be used, and applied with a large soft sponge. Upon no account attempt to *rub* the mud off. It must just be *soaked* off. A full sponge, gently squeezed above the part of the surface to be treated, will allow the water to run freely down over it, and so thoroughly wet and soak the muddy parts, and this can be repeated constantly until all the mud has in this way been removed. Any attempt to brush or to rub the mud off, even if it is thoroughly wet, will inevitably cause scratching and deterioration of the surface. The spoke brush is a fine thing to save trouble; but it is an equally fine thing for removing paint and spoiling finish. It will get the dirt out from between the spokes and from other odd corners in double quick time; but the rubbing of the bristles and also the rubbing of the wood frame—which, however careful one intends to be, is brought in contact with the painted surface—will inevitably do damage and the seductiveness of the spoke brush should be sternly resisted. An exception may be made to the convenient cleaning device known as a water brush, which connects up to an ordinary water supply, and the water issues in numerous streams between the bristles. When all the dirt and mud has been soaked off, the surface can be gone over and gently rubbed with a thoroughly wet sponge, using perfectly clean water, and, preferably, a different and, of course, clean sponge, so that there may be no chance of its pores retaining particles of the grit which have been removed in the previous washing, and when this has been done the surface is then dried off with clean chamois leathers, Selvyt, or silk cloths. Needless to say, the cleaning out of the foot-board and inside body portions of the car where dirt accumulates

is preferably done before the washing takes place, otherwise more work will be entailed in cleaning off the dust arising from this operation. Always see that the chamois leathers and cleaning cloths are kept clean and dry and are used only for the cleaning of the bodywork and upholstery. To use a chamois partly for cleaning the machinery and partly for dealing with the body is a mistake, as the oils and grease thereon will not do the paintwork any good; and this draws attention to another point about which care must be observed, and that is, that neither petrol, paraffin, nor lubricating oil—especially



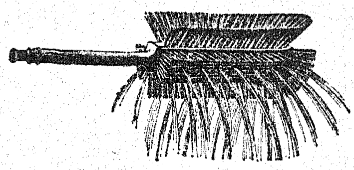
Useful metal bound brush for cleaning engine and working parts of chassis with petrol or paraffin.

the latter—be permitted to get upon any part of the paintwork. If it finds its way there by accident, it must be wiped off instantly, more especially in the earlier life of the car, before the varnish has thoroughly set.

The Proper Cleaning of the Bright Metal Work

Irrespective of whether this is nickel-plated or finished in brass it will require to be constantly and carefully done, if the car as a whole is to present a pleasing appearance, and for this purpose practically any good plate or metal powder can be used, care being taken that the powder is not spilt about, and that any which is so spilt is carefully removed when the cleaning process has been done.

If the leather upholstery of the car becomes soiled, as it will, a wash with soap and water, or some of the special preparations sold for the purpose, will greatly improve its appearance, and if lubricating oil gets spilt about, a prompt application of petrol will do much to nullify its harmful effect, the results of the combination being immediately wiped off with a dry, clean rag, and washing as above follows in due course, with a final polish off with dry, soft cloths. If the car is fitted with a



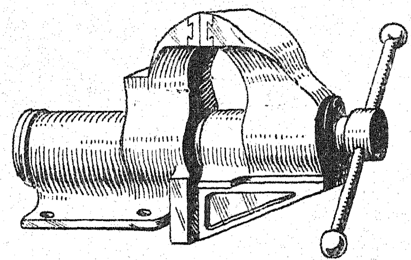
Water brush for coachwork, wheels, etc.

hood, more especially if that hood is leather, it ought always to be kept erected in the garage, so that the tension of the leather is preserved, as, if this is not done, the leather will set in the creases and crack, and the hood, when erected for use on the road, will look untidy. This can be cleaned down in the same way as the leather work of the car body. When dealing with a car which is soiled with dust—that is to say, dry dust—the same care must be used in attempting to rub the dust off, the surface being gone over first with a full sponge and finished off as previously explained.

CHAPTER XIV

The Motorist's Workshop

To the practical motorist with some knowledge of the use of tools and engineering practice workshop accommodation of some sort is indispensable. He takes a pleasure in the executing of minor repairs and adjustments to his car, and the making of mechanical devices embodying his own ideas, with a view to adapting them to his car and increasing the efficiency and pleasure of driving thereof. Moreover, by being able to effect practically all ordinary repairs, he is quite independent of the local garage and repair shop. He thus finds himself able to effect a considerable saving in expenses and he is not subject to the inevitable delays and worries inseparable from the outside execution of orders to one's own ideas. The term "workshop," from the motorist's point of view, is a somewhat elastic one. It may mean anything from a well-equipped mechanic's shop on which a considerable outlay has been expended, down to a simple working bench rigged up

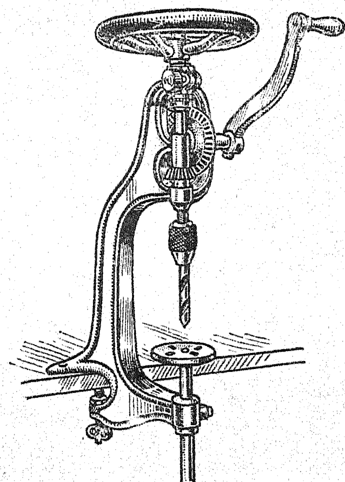


Parallel jaw bench vice. Indispensable for the workshop. The jaws are of hardened steel and are renewable.

in the motor house, converted stable, or whatever place in which he may store his car. There are, of course, quite a considerable number of enthusiastic amateur mechanics and car owners who take a great pride in their workshops, having them fitted up in the most up-to-date manner with lathe, drilling and planing machines, etc., and even to the extent of having electric motive power and lighting. The majority of practical motorists can as a rule arrange for at least a working bench being fixed in the car house, and on the bench a vice can be fitted. It is indeed surprising what a great deal of useful work can be done with the usual equipment or kit of tools with which every car is, or should be, provided, and a bench on which to work. In deciding upon a suitable position for the working bench, if it is at all possible to fix it where there is plenty of light, say, alongside a window, this should be chosen in preference to elsewhere. It is a great handicap to reliable work to have only a mere glimmer of daylight available and to work mostly by artificial light. If there is room available a bench 8 or 10 ft. long will be found most useful.

Several types of working bench, properly fitted up with drawers for tools, racks and shelves for parts and materials, are now obtainable should the car owner not wish to have one specially made. In the latter case it should be of a solid structure, well made and fixed by a practical wood worker. It should be 2 in. thickness of well-seasoned pine, or, better still, birch, or a combination of the two. The harder wood is capable of keeping its surface despite hard knocks and rough usage, whereas the softer woods are easily knocked about. Regarding the height of the bench it is very desirable not to have it too low, as this makes it

awkward to work at and strains one's back. A good average height is 3 ft., which will allow of the operator having a good command over the vice, but it is a simple matter to suit the height to one's individual requirements. As to the width of the bench, from 2 ft. to 2 ft. 6 in. will be found ample. The vice and its fixing next claim attention. It is certainly worth while as one is about the work to purchase a useful tool and not a toy. A high-class parallel vice with steel jaws that will stand hard service is alone admissible. As to the best size, 5 in. jaws are preferable, or not less than 4 in. The average cheap "amateurs'" vice has a painful tendency either to break in two the first time it receives a hard knock, or, if not, the jaws refuse to meet, except perhaps at one corner. A convenient position in which to fix the vice is within a foot of the left-hand end of the bench, excepting of course in case this end of the bench abuts up against a wall which would prevent one getting elbow room to work. Regarding tools the usual supply found in the car tool kit will require to be added to, and



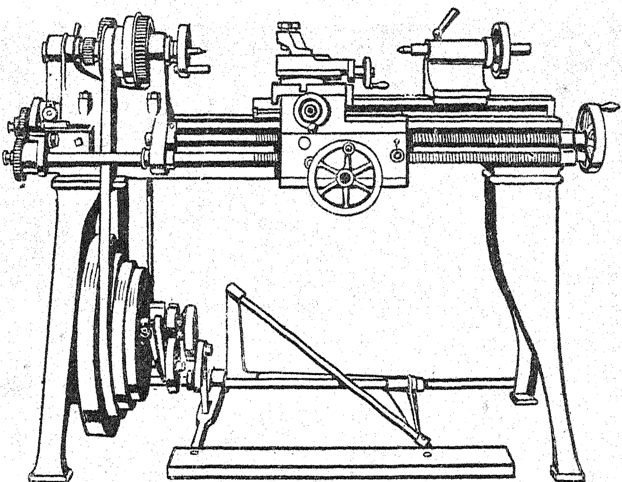
Bench drilling machine with adjustable drill chuck. This useful tool can either be permanently screwed to the bench or clamped on when required. It can also be had with two speeds for fast or slow drilling, according to the material being drilled.

these extras are best kept in a drawer fitted in the bench or in a tool rack. A small grindstone and also a small emery wheel for grinding purposes should find a place in the shop. This latter is a most useful tool and an inexpensive one, which clamps to the bench and is driven by a treadle or hand gear arrangement which runs it at a very high speed. No workshop is anything like complete without a lathe of some kind. Of all mechanical tools this is, par excellence, the one adaptable to all kinds of mechanical operations. Turning, boring, screw-cutting, milling, grinding, polishing, drilling, slotting, sawing, wheel cutting, all come within the scope of a good lathe, and if one decides to complete the workshop equipment with a lathe, it certainly pays to go in for a tool which has been designed for the class of work for which it will be most used.

Lathe Equipment

Treadle driving is a *sine quâ non,* and with a heavy flywheel having roller bearings there is power available to do any required repair, or make any part of a motorcar that can be made on a lathe. An indispensable adjunct to the motorist's lathe, which saves time and the

improvising of fittings is a three-jaw chuck having independently-operated jaws. These chucks are known as the Cushman type, and they can grip anything from a needle to a piston. Such a chuck 5 in. diameter will meet all requirements. The fact should be noted that three *independent* jaws are preferable to the self-centring type, and for this reason the latter will certainly grip objects true when it is new and carefully handled, but under the stress of wear and tear it loses its accuracy. On the other hand, if each jaw can be adjusted separately the object can always be set dead true, as wear and tear does not affect



Screw-cutting lathe for general motor repair work. Treadle drive. This lathe can equally well be driven by power if available by means of an overhead countershaft, or the drive can be taken direct to the flywheel from an electric motor, bolted to the floor.

the efficiency of the chuck. A reversible set of jaws is also an advantage, as large circular parts can then be gripped truly and securely and much time is saved in mounting.

Amongst generally useful equipment will be found a small bench drilling machine, bench hack saw, brazing lamp, and small vulcanizer.

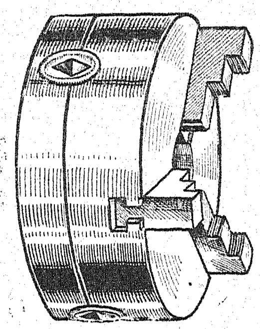
Electric Driving

With any usual lighting supply of continuous or alternating current 100 to 250 volts available a small electric motor is by far the most convenient source of workshop driving power. For the usual lathe, drilling machine, grinder, circular saw, etc., the minimum power motor advisable is $\frac{1}{2}$ b.h.p. A larger motor of $\frac{3}{4}$ or 1 b.h.p., however, should be installed if possible, as the margin of power is very useful at times and the running costs are no greater than with the smaller motor.

Hardening Small Steel Parts

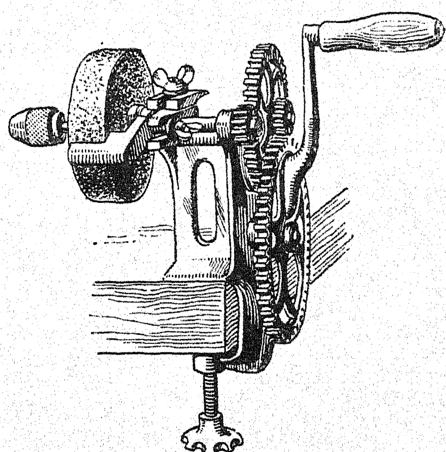
Car owners sufficiently versed in mechanical practice to do their own small repairs occasionally wish to know the most convenient way of hardening steel parts, such as small pinions, bushes, nuts, cotters, and similar articles. Certain parts are better made from mild or Bessemer steel, rather than from tool steel; good quality iron may also be used. It is not difficult to harden such parts on the surface, leaving

the mass or interior of the metal soft. The part in this condition is not so liable to break under shock or wedging action. It is possible to case-harden small pinions quite well by bringing them to a uniform bright-red heat and plunging them into finely-powdered yellow prussiate of potash, repeating the operation three or four times, and finally plunging into clean cold water whilst still at a red heat. The mild steel absorbs carbon from the potash to a depth of about half a millimetre, and this surface hardens perfectly on the final cooling. Nuts so treated resist rough usage with the spanner much better than an ordinary soft-surfaced nut. In treating parts of this class it is, however, important to remember that the threaded part should be filled up with clay, so that it does not come in contact with the carbonizing



An indispensable lathe accessory is the three-jaw chuck, with separately adjustable jaws. The jaws are also reversible, and thus a wide range of work can be gripped and centred. This type of chuck has an advantage over the self-centring type insomuch that use and hard work do not affect the accuracy with which the part gripped can be centred.

material; otherwise it will be certain to be spoiled. Any roughness of the surface, such as on the teeth of pinions, can be smoothed off with emery cloth wrapped over a thin flat file. Parts made from tool, or high carbon steel, are readily hardened by making them red hot and plunging them into cold water. The correct heat is important, because if the parts be heated to a very bright red, they may be spoiled or decarbonized, and, if to a white heat, certainly so. On the other

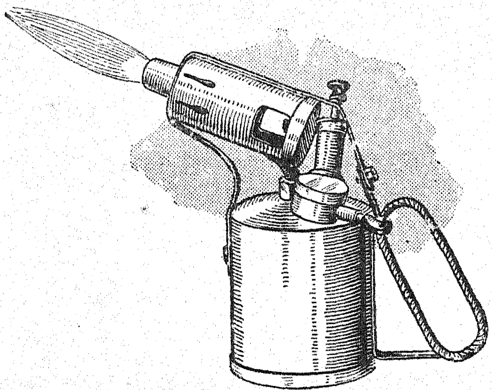


High-speed emery or carborundum wheel grinder, with drill chuck attachment. This very useful appliance sharpens many kinds of tools, such as drills, chisels, cutters, &c., as well as being useful for trimming up castings and hard metal which cannot be filed.

hand, if made barely red, the parts will not harden. Another important matter to remember, in hardening parts, such as pins, drills, and cutters, where the length is much greater than the diameter, is that they must be plunged into the water in the direction of the length—straight down and not horizontally—or twisting or warping is sure to occur.

Methods of Tempering Steel

A spring can be hardened and tempered nicely by heating uniformly to redness and plunging into ordinary engine lubricating oil, then withdrawing and burning off the oil in the flame, that is, to hold the spring in the flame till the oil has just flashed off and then withdrawing it. It is useful to know how to "let down" a hardened part. One often notices on exhibition chassis gearwheels and similar

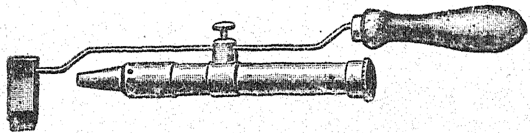


Automatic blow-pipe, using benzoline or petrol. The flame is intensely hot, and this appliance is invaluable for soldering, brazing, forging and tempering small tools.

parts which have a rich deep yellow surface coloration. This denotes a particular degree of tempering; the parts are made less hard and brittle than when they come out of the water, which leaves them "dead hard." A part to be tempered must first be cleaned up and polished to a fair surface before making "dead hard" in the way described. After this they have to be lightly cleaned up again, which is quite easily done with fine emery cloth. There are then several ways of proceeding. A very small part can be fixed to a piece of steel wire and very cautiously held in the Bunsen flame (or the blow-lamp flame) till the polished surface takes on a uniform straw colour. The instant this is attained the part must be plunged into water. The part can be kept in the flame longer till a deep straw colour merging into purple is attained and then cooled off. It will be slightly softer than before. It can be further "let down" to a blue colour, when it will be soft enough to file with difficulty. Drills and small tools can be tempered quite well in a flame. Larger parts are better tempered on an iron plate on which has been placed a thick layer of fine sand and the flame allowed to play underneath. This ensures the part being uniformly tempered.

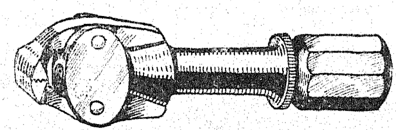
For making drills, cutters, small chisels, taps, drifts, and other small tools the best material is that known as "Silver Steel," which is sold in a wide range of thicknesses from $\frac{1}{16}$ to $\frac{3}{4}$ in., and in square and circular section.

To solder metal work properly requires practice and judgment. Some classes of work can be soldered with an ordinary copper bit, others require the use of a flame from a Bunsen burner or blast-lamp to raise the necessary heat. Cast-iron is very difficult to solder, and aluminium requires special fluxes and manipulation. Repairs to crank chambers of aluminium are best effected by an aluminium worker. Light work in wire, sheet and tubes of copper, brass or iron can be soldered with an ordinary bit or in a Bunsen flame. The essentials



Automatically heated soldering bit with spirit burner using petrol or alcohol.

are thorough cleanliness from grease and oxide of the parts and the copper bit, a suitable flux, some good quality or " fine " solder, and the bit brought to the right heat. The ordinary flux known as " killed spirits " is made by placing zinc clippings into strong hydrochloric acid till no more will dissolve. Special preparations such as " Fluxite " give very good results in soldering and are not corrosive. Work soldered with spirits should always be thoroughly washed afterwards. Cored solder is very useful for some work, as it contains its own flux. The copper bit should always be kept well " tinned " and never heated to redness. To solder a large tank or radiator the water should be run out, the place to be soldered well prepared, and a large copper bit used, preferably one automatically heated by a blow lamp. Such a repair is not easy to make, owing to the large cooling surface of



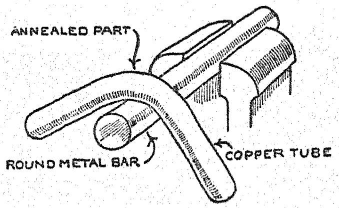
Hand vice. A useful tool for gripping small parts whilst being filed, etc.

the metal. The tank or radiator may have to be taken off the car to do the repair conveniently. A soldered joint, of course, will not resist much strain or vibration, and in some cases it is advisable to reinforce a repair by riveting. A brazed joint is much stronger, but brazing is a much more difficult process than soldering and best left to a skilled hand to do. Small soldered repairs can be made whilst on the road very easily and conveniently by the use of a special outfit consisting of a small methylated spirit blow-lamp and a copper bit, which is supported in a clip, the flame playing continuously on the copper bit whilst the repair is being effected.

Miscellaneous Hints

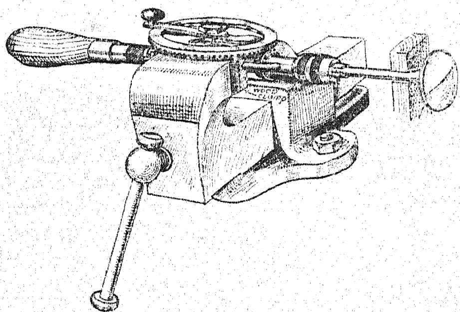
One of the items most often required in the motor-house is a washer of a particular size and thickness, and as often as not it proves that what one exactly requires is not to be found in the spares box. A washer of a specific thickness is often wanted, for instance, to take up a small amount of backlash or end-play in a shaft. In a case of this kind the plan may be adopted of obtaining a washer thicker than

required and carefully filing down. To file a washer sounds easy, but, handled in the ordinary way, is diffic. lt to deal with. If one tries to grip it in the vice by the edge it either springs out or rocks about in an annoying manner, and, in any case, it is impossible to file a washer thin and flat in this manner. The operation is made easy ıf the washer is first pressed between the jaws of the vice into the surface of a piece of soft wood endwise of the grain. In filing, the wood and



Bending a copper tube.

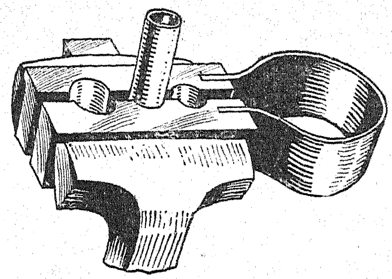
metal are cut away together, and if the file be used skilfully the washer can be removed from its bed as true and as thin as may be desired. For enlarging the centre hole, if necessary, as large a round file as can be got through should be used, and with a little care a hole can be made that will be as true as if drilled. For making very thin washers an excellent material is sheet phosphor-bronze, which can be obtained from 1-64th inch down to the thinness of tissue paper. Using a pair of spring dividers, one can strike out any size washer in a minute or two. Very useful material to have about



An ordinary geared hand drill clamped in the vice can be used for touching up a valve or filing a taper pin when a lathe is not available.

the motor-house is a few feet of the thin soft iron strip, from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. wide, which is used on the edges of packing cases. It can be fashioned into excellent clips by the aid of the pliers and a round metal bar of suitable size on which to bend it. Amongst the box of spare nuts and bolts there should always be a dozen or so 3-16ths (Whitworth thread) round-headed bolts of various lengths, with square nuts, and then one need never be at a loss for a clip. A usual motor-house operation is making a sharp bend in a copper petrol pipe; for example, if a new carburetter is being fitted. The novice usually makes the bend all right, but stops the pipe up at the same time. To make a uniform bend requires care and experience; for anything over

5-16 in. diameter the pipe would have to be temporarily filled with lead, and preferably bent round a tube-bending machine. Very fair bends can be made by heating the pipe at the desired place in a Bunsen flame till red hot, and cooling in water, and then bending a little at a time round a bar held in the vice. The amount of constriction at the bend is very slight, especially after touching up with a ball-pened hammer. A small taper pin is often required for some part of the engine. One way—the usual one—to make it is to file it up from a piece of steel rod in the vice. Unless skilfully done, a lop-sided, ill-fitting pin is the result. A better plan is to grip the hand-drill, which every complete tool outfit should contain, firmly in the vice, fix a piece of steel rod of suitable diameter in the chuck, arrange a notched piece of wood under the steel rod, and file it down with the right hand whilst one turns the drill handle with the left. By this means as well fitting a pin can be made as if turned up on a lathe.



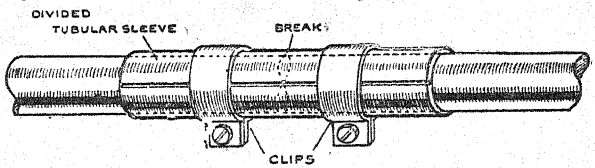
Tube grip or clamp for holding tubes in the vice.

Easing a Tight-fitting Sparking Plug

Many motorists have experienced a difficulty with a tight-fitting bolt or screw, perhaps a sparking-plug, and it is rarely that one is provided with suitable stocks and dies to ease the threads. By patient use of a " V " or knife-edge file worked slowly along the thread, turning the latter round meanwhile, it can always be eased down to a working fit. The right kind of file, however, must be used—a half-round file will spoil the thread. This method is also useful for touching up a burred thread, so often the result of gripping a bolt or threaded part in the vice without any protection over the jaws, the fine steel teeth of which being dead hard, will crush anything softer. Clamps over the vice-jaws should invariably be used when any finished work has to be gripped. A pair can be made in a few minutes from a piece of soft sheet copper, although for some work sheet lead clamps give a better grip. A good hold of a circular bar cannot be obtained by simply gripping direct between the jaws, as the pressure is practically only along a line, and moreover it is risky with a tube, as this is likely to be crushed. A pair of wood grips can easily be cut from two oblong pieces of hard wood, two semi-circular channels being made large enough to grip the largest circular piece likely to be used. Smaller diameter work can always be lapped round with paper to make it fit. Handled in this way, a bar or tube need not have a scratch left on its surface after leaving the vice. Regarding drilling holes, an operation so frequently necessary, there are a few points to observe.

Use of Drills

Fluted drills are the best, as twist drills are so very liable to grip in the work and often break, especially in drilling through a piece of thin metal. A drill should be really sharp; blunt drills cause extraordinary exertion for little result, whereas a sharp one requires only a moderate pressure to work. Brass, gun-metal, and cast-iron are best drilled dry and wrought iron and steel with a little thin oil on the drill point. Some kinds of cast-iron are exceedingly hard on the surface, and the drill at first will hardly make any impression. Making a deep centre punch mark will generally facilitate matters When a large hole, say from ⅜ in. to ¾ in. diameter, has to be made, it is better to drill a small hole first, really a pilot hole, to guide the larger drill, otherwise there is great risk of the large drill running all to one side of the place desired. Hard steel, of course, cannot be touched with an ordinary drill; the metal must first be softened by leaving in the fire till just an even red heat is reached, and then burying it in some sand till it cools. Re-hardening is not so easy, as some parts split or twist easily when plunged at a red heat into cold water. Caution must be used in the operation. Quenching in oil is safer, but the part cannot be made so hard. The metal saw is a very handy tool, but the hardened steel blades are exceedingly brittle, and any twist or crookedness in the sawing operation causes a breakage.



An emergency clamp for a broken rod or shaft, which is not required to transmit a driving torque. A fractured exhaust pipe can be also held together in this manner, sheet asbestos packing being used.

How to Use the Metal Saw.

The fine-toothed blades should be used for iron and steel and the coarser ones for brass and soft metals. For cutting through a brass or steel tube use a fine-toothed blade, as the teeth rip off the coarse ones. Before sawing make a true circumferential line round the tube where the cut is desired; then, by turning the tube round a little between each cut, the latter will be true and square. The broken blades are useful at times for small repairs, as they are readily softened. Spiral springs are so readily obtained in a large variety now that it is not often one is at a loss for a particular size of spring. The occasion may arise, but it is worth keeping in mind that the hand drill fixed in the vice makes a first-rate winder for small springs, using a piece of round steel rod as a mandril.

Removal of Tight or Broken Screws.

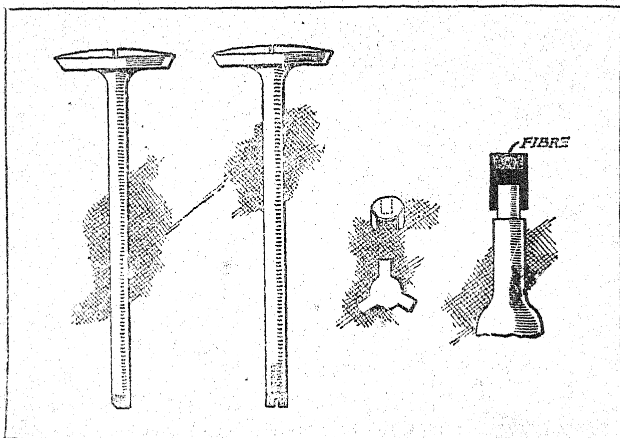
The removal of a tight screw often presents a problem. Providing the slot in the screw head be intact, the extra leverage of a spanner applied to screwdriver may have some effect, but the difficulty arises when the slot in the screw head is worn or burred over and practically non-existent. In this case the slot must be recut, and this can be done by means of a very small chisel ground down to a very narrow cutting edge. Sometimes a screw can be started by applying a chisel and giving it a smart tap to the left tangent-wise.

As a last resource the screw or stud must be drilled out so that a mere shell remains, which can be removed by re-tapping the hole.

Miscellaneous Repairs: Valves, Tappets, &c.

In the case of a broken steering tie bar or any rod or shaft of circular section the ordinary splint class of repair is necessarily of a very temporary nature, and has to be treated very considerately, or it will soon go to pieces under road vibration and driving stress. A very much stronger repair can be made if a suitable length of iron pipe, or, better still, steel cycle tube, the same internal diameter as the fractured bar, is carefully sawn in two lengthwise and a series of clamps made from the strip iron aforementioned distributed along it. After this is screwed up tight, the piece will not be far, if any, short of its original strength.

Steering knuckle pins may be lost; in this event an ordinary bolt with the squared part of the shank filed off approximately cylindrical



The illustrations depict: Valve stem lengthened by having a piece of steel brazed or riveted on. Another method: a steel screw fitted into end of valve stem which is suitably drilled and tapped. Cap made from sheet steel to fit over top of valve tappet for taking up clearance. Cap turned from bar steel fitted with fibre inset for silent working.

may be substituted. A small hole to take a split pin should be drilled at a suitable position to keep the bolt from jumping out of the knuckle.

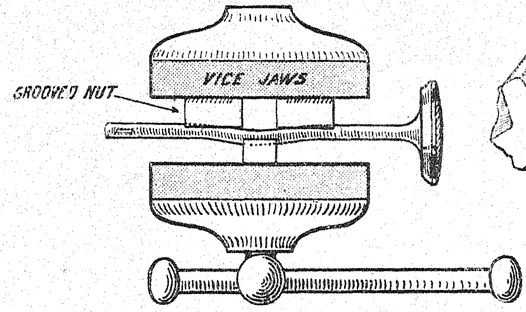
Temporary Valve Repair

It is rare nowadays to experience broken exhaust valves; it is, of course, advisable to carry one or two spare valves, but, at the worst, if the valve head remains intact, it could be fitted on a new stem. A piece of mild steel rod about the size of the stem required is necessary. The head of the valve is filed down to allow of drilling exactly central rather smaller than the stem; this latter should then have a shoulder filed at one end to drive very tight through valve head and project through a full $\frac{1}{8}$ in., so as to allow of riveting over securely. Instead of having to cut a slot in the stem to take the cottar in the ordinary way, a small hole can be drilled through the stem and the end of the spring hooked into it. The end should be softened in a flame and bent at a right angle. The cutting of a slot is not an easy process, whereas the end of the spring may, with a little persuasion, be made to enter the

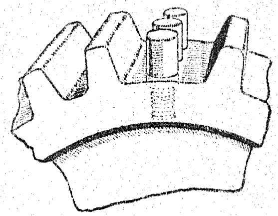
hole, and it works just as well. With a built-up valve, such as described, it is necessary to allow a good clearance at the tappet, because after a short time the head will probably draw away from the stem a short distance, and if the tappet be set too close the valve will remain open. If the stem be screwed into the head tight and then riveted over, the head cannot shift; this plan should be adopted if possible.

How to Remedy a "Stripped" Nut

One of the most annoying experiences is to have a stripped nut which one cannot conveniently replace. It is usually a special size nut with a fine thread which goes wrong. A method that may be adopted is to re-line the nut uniformly with soft solder and then give it a start on the bolt, and by working it down the thread a little at a time cut a new thread inside the nut. The soldering part of the



Method of straightening a bent shaft or rod such as a valve stem. The vice is used as a lever. The supports are grooved and adjusted to suit the bend. A final straightening can be given by carefully hammering the rod with a copper-headed hammer on a steel block. A steel-headed hammer must not be used as it bruises the metal.

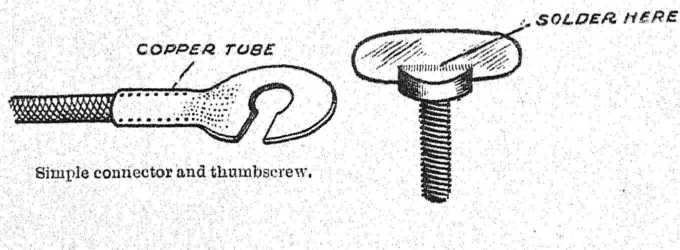


Method of repairing a pinion wheel having a broken tooth. A row of steel pins are tightly screwed into position as shown, the shoulder being recessed to give support to the pins. The pins are trimmed up with a file to approximate to shape of a tooth.

operation is simple enough, the nut being fastened to a piece of iron wire, dipped in the killed spirits, and then held in the blow-lamp flame till hot enough to melt the solder. The same process reversed would apply equally well to a stripped bolt and the nut used to cut a new thread on it.

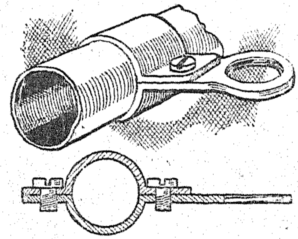
Useful Mechanical Fitments

The series of sketches shown are practically self-explanatory. An ordinary screw can be converted into a thumbscrew for quick detachment without using a screwdriver by driving and soldering into the slot a slip of metal (steel or brass) and trimming the edge and corners with a file. Screws so converted are very convenient for fitting on the carburetter, contact maker, covers, etc. A terminal end is shown which



Simple connector and thumbscrew.

is easily made from a piece of soft copper tube from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. thick. The stripped end of the cable is passed into the tube and the end of the tube carefully spread out by hammering. A suitable-sized hole is drilled and slotted through to one side with a file. The corners are then neatly filed round, and the faces, if necessary, trimmed up



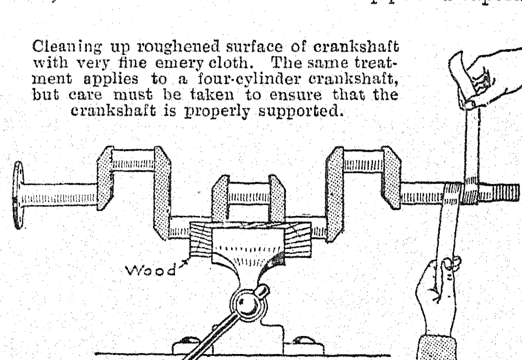
A useful fitment for testing sparking plugs. It can be permanently screwed to the induction pipe, and the plug to be tested can be screwed in from below, thus enabling the spark to be examined. It is an improvement on the usual plan of resting the plug on top of the engine.

flat. This terminal end can be attached and detached without removing the milled head of the terminal or plug.

Aid to Easy Starting

There are various attachments sold for the purpose, but if it is not desired to go to the expense of fitting one of these, the following plan can be adopted. Obtain a length of $\frac{1}{4}$ in. copper tube to reach from the dashboard to the inlet pipe close to the cylinders. A small oil cup with tap is fitted at one end of the pipe, the other end entering the inlet pipe through a hole, which it closely fits. The cup is secured to the dash by a clip in a convenient position. Some petrol, or preferably petrol and ether mixed, is placed in the cup, and at starting the tap turned on, so that it will run into the inlet pipe and vaporize easily.

Cleaning up roughened surface of crankshaft with very fine emery cloth. The same treatment applies to a four-cylinder crankshaft, but care must be taken to ensure that the crankshaft is properly supported.



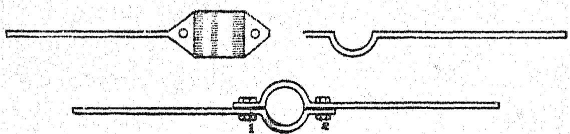
Engine Overhaul

Engine overhaul should only be undertaken by experienced hands, or else be carried out under the guidance of someone conversant with the practical part of the subject. The most important parts of engine overhaul are those which deal with the crankshaft and bearings.

When the engine has been dissembled the crankshaft should be examined. If any rings, or ridges, can be seen, or felt, these are

indications that the lubrication has failed at some time or other; the crankshaft should be held in the vice between grooved wood blocks, and carefully emery-clothed. To do this properly, some fine emery-cloth (No. FF) should be torn into strips about 1½ in. wide, and well oiled, and the cranks smoothed up, as shown in the illustration. Emery tape is better for the work when obtainable. If the emery cloth completely encircles the shaft, and a long, steady movement be imparted to it, there will be no tendency to make the latter oval. It may be found that a crankpin is not only scored but, on testing with callipers, is found out of truth, i.e., not perfectly circular. The usual and best plan is to have the shaft ground true on a special grinding lathe, but this may not always be possible owing to lack of facilities.

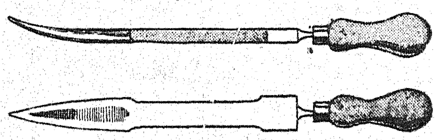
The best alternative is to, first of all, file up (with a very smooth file) the untrue part of the shaft to as accurate a circular shape as possible, testing frequently with callipers. A lead "lap" is then made in clamps as shown in the sketch. This is bored out to size, and paper or card packing inserted between the two halves so that the halves can be gradually closed down by the bolts on to the crankshaft. The lap is dressed with flour emery and oil and worked round the crankpin by hand till a good surface is obtained.



A grinding tool or "lap" for truing up a worn shaft when a proper grinding machine is not available.

Trimming Up the Brasses

Having satisfactorily done this, the ridges in the main bearings should be carefully scraped away. The scraping tools are made from worn-out half-round files which are carefully ground up on a grindstone. Then the crankshaft should be placed in position on the lower half of the crankcase and the bearings bolted in position. It will then probably be found that there is some slackness, and if such is the case the faces of the two halves of the bearings should be lightly draw-filed until the

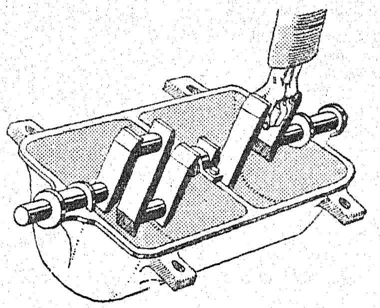


Scraping tools for truing-up bearings.

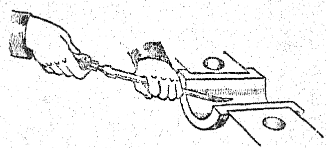
shaft is a better fit. Next the top halves and crankshaft should be removed and the surfaces of the bearings smeared with a thin mixture of red lead and oil. Replace the crankshaft and tighten the bearings down. Then give a few turns by hand. Again remove the crankshaft. The parts of the bearings showing bright should be carefully scraped. This process should be repeated until the surfaces of all the bearings are smooth and level. Before finishing, it should be carefully noted that the oil channels are of sufficient depth. Scraping is not easy work, and requires a fair amount of skill, so it is advisable first to practise on an old bearing. When the main bearings are completed, the connecting-

rod big-end bearing should be treated in the same manner. Also the camshaft bearings should be scraped if they need it. When at work on the bearings, it should be remembered that metal once taken away cannot be replaced unless new parts are fitted, so extreme care should be taken.

Care must be taken not to adjust bearings too closely or seizure will probably result. The crankshaft should not be too stiff in its bearings that it cannot be turned round by grasping with the hand. The connecting rod bearings should not be tighter than will allow the connecting rod to just swing over by its own weight. If the small end bearing of the connecting rod is worn it will be necessary to make a new bush and reamer it out to a true fit on the gudgeon pin.



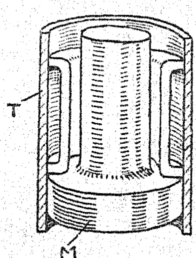
Testing crankshaft in bearings.



Using a scraping tool on a bearing surface.

Re-metalling Bearings

Many engines have what are known as "lined" bearings, the working surface consisting of a white metal alloy which is melted on to the bronze shell. The chief advantage is that a bearing on this principle is safer than a plain phosphor-bronze bearing, insomuch that, should the lubrication fail by any mischance, the alloy lining will melt out by the heat caused by friction and thus prevent a seizure of the shaft and probably a smash-up. The fine polished surface is, moreover, a very suitable one for the shaft to work in. The operation of re-metalling



Device or mould for re-metalling a bearing.

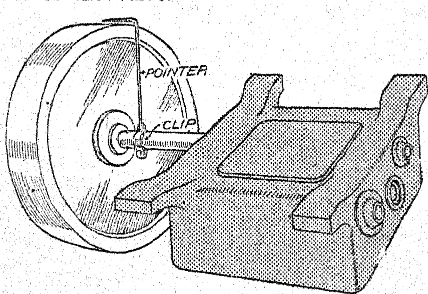
bearings when worn is one for a well-equipped repair shop to undertake, as it largely necessitates skilled work at the lathe. Briefly the method consists in melting off the old lining from the bronze shells by means of a blowpipe and then placing them truly in a "jig" or mould (T) which has a central core (M) rather smaller in diameter than the engine shaft. Into the annular space between the core and shell new melted metal is

run, the bronze shell being previously well tinned with solder and made hot by the blowpipe to enable the new metal to adhere properly. When the metal is set the central core is taken out and the bearing is bored and faced to exact size in the lathe, after which it is sawn centrally across and adjusted into position in the usual way.

The Valves and Piston Rings

Some general information has been given on these details in a previous chapter, but the treatment may be summarized. The valves should be ground in to ensure good compression.

If the valve surfaces are not badly pitted, a touch of flour-emery and oil will do the work excellently. A simple method of grinding-in is to use an ordinary carpenter's brace, with, of course, the end of a screw-driver replacing the bit. The valve should not continuously be revolved in the one direction, but reversed about every half-a-dozen revolutions. It is a good plan to have a spring beneath the valve so that, when the pressure is temporarily taken off, the valve lifts and changes its seat. When the valves are in place the tappets should be adjusted to give 1-64 in. clearance between the tappet and the valve stem. If there are any grooves or burrs on the cam surfaces caused by the constant action of the rollers, these should be lightly " touched up " with a file wrapped round with emery-cloth, or a better way is to give the cam a very light touch up on a fine emery wheel, taking great care not to alter the shape of the cam or remove any appreciable amount of metal, as this would reduce the lift of the valve.



Device for centring shafts of gearbox and clutch.

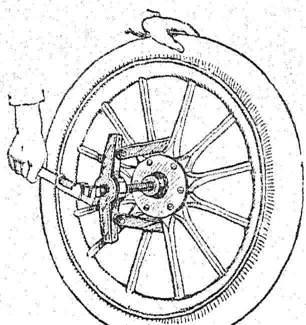
With regard to the pistons, the rings should be taken off and thoroughly cleaned, and the piston ring grooves also. Any burr that there may be should be removed. To take off the rings, a few pieces of tin, or steel rules, should be slipped underneath according to the previous instructions. The maker's marks should be noted, and each ring carefully placed back in its original groove. The removal of carbon deposit should be thoroughly done, the piston tops and inside of combustion chamber being well scraped.

Information on the various processes applicable to the removal of carbon are given in the section dealing with engine knock.

Testing Shaft Alignment

To ensure freedom of running and absence of any binding or friction on the engine and gearbox bearings, it is very important that the centres of the respective shafts exactly coincide. When the engine is

overhauled the setting of the crankshaft with respect to the gearbox shaft should be carefully tested. The simplest way to do this is to arrange an indicator on the gearbox shaft, as shown in the illustration. This consists of a stiff, straight piece of wire clipped to the shaft, and it is bent at right angles in the form of a pointer. If the centres of the shafts exactly coincide this pointed end will clear the edge of the flywheel an equal amount all round. If the centres are slightly out of alignment the pointer will be nearer the flywheel edge at one part of its circumference than at another. By having a sliding adjustment to the pointer a very accurate setting can be made. The gearbox can always be slightly packed or raised by means of very thin sheet metal, placed under its bearers to effect any adjustment required.



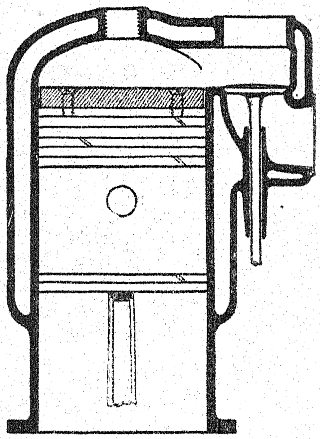
The withdrawal of an ordinary non-detachable wheel from the axle is best effected by a special tool as illustrated. This exerts powerful screw pressure against the axle and gives an even central pull on the wheel by means of the hinged arms which have end-pieces to press against the hub flange.

Repairs to Steering Gear

Backlash in the steering is a most difficult and elusive trouble to cure. Whilst a certain amount of play between the steering wheel and the stub axles is desirable, it is the experience of almost every motorist that this freedom increases unduly with the age of the car until steering is rendered difficult, and even dangerous. In most designs of steering mechanism employing the usual worm and sector, the lever which is carried and actuated by the sector has a ball-end operating between coil springs. (See diagrams in section on steering mechanism.) These springs provide the flexibility which is necessary between the steering wheel and the front wheels. Any undue backlash which may have developed in the course of time can be traced to any or all of these parts of the steering gear, the worm and sector, the adjustment of the springs through which the steering arm is actuated, and the pin joints of the cross rod and stub axles. The two latter cases can be quite easily rectified, and with an old car it may often be worth while to go to the trouble of making leather coverings for the joints, which will keep mud and grit out and grease in.

Having corrected any slackness in the external connections by renewing pins and bolts where necessary, if it is still found that there is excessive backlash in the steering, it proves that the worm and sector are much worn and demand attention. It will almost certainly be found that there is the maximum amount of play when steering straight, whereas there will be very much less on full lock. This state of affairs denotes wear of the sector rather than the worm, and wear in one part only, namely, that which is most constantly in

action. Moreover, it also suggests a remedy which has been adopted by some makers, namely, the fitting of a complete worm wheel instead of a sector, so that, when one portion of it is worn it can be turned round to another part as yet untouched. In the case of old cars, however, with the more usual type of sector, it appears at first sight that there is no remedy available short of a complete renewal. Much, however, can be done in the way of compromise. First of all there may



Compression plate (shaded part) of aluminium screwed and riveted to the head of the piston to increase the compression in a low compression engine. The thickness of plate required will depend on the degree of compression desired, but it will rarely be necessary to use thicker than $\frac{5}{16}$ths inch. An improvement on the plan is to fit a steel piston of the necessary increased length.

be end-play in the worm, which can usually be taken up without much difficulty. Secondly, either the bearings which carry the worm or those on which the sector works—more particularly the latter—may be slack, in which case rebushing will effect an improvement. If ordinary bushes for the bearings of the sector do not sufficiently reduce the backlash they should be turned eccentrically, and inserted so as to bring the sector slightly nearer to the centre line of the steering column. This plan, however, should only be adopted as a last resource, and great care must be exercised in its execution. The worm must not be allowed to bottom between the teeth of the sector, and the alteration must strike a compromise between that part of the sector which is most worn and those parts which come into operation on full lock, which must not be too tight.

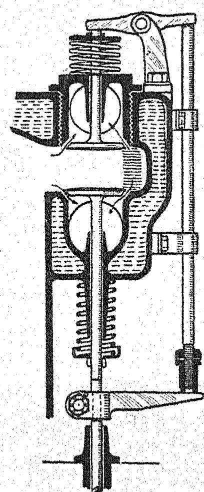
Improving an Under-powered Engine

It is often required to know of some simple and inexpensive means of obtaining more than the normal power from an engine. The least expensive methods have the disadvantage of being in the nature of experiments. The one plan about which there can be no uncertainty is that of fitting a larger cylinder and piston, and even in this case, to obtain a really satisfactory result a less increase than 10 millimetres in the bore is not desirable, in view of the expense incurred. It is quite practicable to enlarge the bore of many old cylinders as much as 4 millimetres, but if one works out what the increased cubic capacity thereby obtained means in extra power, taking power developed as being directly proportional to cylinder capacity, it will be found that there is not much in it. Of course, one should not confuse the practicability of "restoring" the power of an old-type engine with that of "increasing" its normal output. The cylinders may be a good deal worn and thus allow considerable explosion and compression leakage to

take place. Obviously, accurately reboring the cylinders and refitting new pistons is the correct plan to adopt to restore the power; and the expense in this case is usually warranted.

Some Suggested Methods

The plan of adding an auxiliary exhaust port to the cylinder has been found to give good results in engines with limited exhaust-valve opening. On certain engines it has been found possible to fit valves of larger diameter by boring out the existing seatings. This, in conjunction with a larger exhaust pipe, with acute bends eliminated, has given good results. Even fitting an additional exhaust valve per cylinder has, in certain instances, been found feasible, with some ingenuity displayed in devising actuating mechanism. Fitting dual sparking plugs, with a series connection, has become a popular experiment in attempts to increase power of the engine. There is also the



Method of fitting an extra overhead exhaust valve by utilizing the valve port cap, to which an exhaust outlet must be provided. This applies only to old-pattern engines with inadequate exhaust valve area. A new valve port cover may have to be made of sufficient depth to allow of the exhaust outlet connection being made.

method of increasing the compression of old-type engines. It is a simple plan, certainly, to rivet an aluminium plate, from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. thick on top of the piston, but one never knows how this will turn out short of a prolonged test. It may be found that, although the car is much faster on the level, it will not take hills so well as previously, because, when forced on full cylinder charges, the higher compression causes pre-ignition and very pronounced "knock." The only plan to adopt then is gradually to reduce the thickness of the compression plate, in order to give the amount of compression the engine will stand on average work. The excessive weight of the pistons and connecting rods of some old-fashioned engines is not conducive to obtaining the necessary rate of revolutions for a large power output. A good proportion of this undue weight may be judiciously eliminated by drilling the pistons and connecting rods and the strength in no way interfered with. Many old-pattern engines have been improved without any structural alterations simply by fitting an efficient modern carburetter and a high-tension magneto in place of the coil. A magneto, by reason of the great accuracy of the spark timing, is an important factor in getting maximum power.

Gear-box and Crankcase Repairs

Fractured lugs are a common sort of repair with these parts, and although extemporized repairs are possible in an emergency, the parts should be sent to an aluminium repair specialist as soon as possible, as permanent and well-finished repairs can always be made with a minimum of delay.

Modernizing Old-type Cars

This is a speciality now being undertaken by several concerns, and many a sound car of reputed make can be transformed into something like up-to-date design at a cost which does not warrant disposing it at a sacrifice. The engine and transmission, wheels and frame, can generally be left as they are, and improvements made by fitting a new radiator, bonnet, dashboard, raking the steering, fitting a magneto, etc.

The bodywork generally calls for some special treatment, and much is possible in this direction. More extensive conversions can be made, even to the extent of lengthening the frame and putting on a new body, and fitting wire wheels; but obviously the expense entailed in this work has to be seriously considered as to the plan being economically sound.

Frame, Radiator and Lamp Repairs

These can only be referred to insomuch as to say that, as a rule, such repairs are quite outside the scope of the mechanical amateur. Nowadays a number of concerns specialize in such repairs, and have laid down extensive plant for the work, and the results they are able to produce with material so badly damaged as to appear hopeless are surprisingly good. Chassis frames that have been bent or even fractured in collision can be straightened under the press, and acetylene-welded as strong as when new.

Similarly, weak frames can be stiffened and braced up. When a radiator or lamp is damaged it is generally found in a rather bad state, but the resources of the motor sheet-metal worker are so extensive that, except in a very small proportion of cases, it is seldom beyond repair. The parts can be straightened out, re-spun and brazed-up, or soldered and finally polished and plated. New lenses, front glasses, and mirrors are sufficiently standardized to be fitted without difficulty, even to lamps of obsolete or special pattern.

Fuel Economizers and Energizers

To effect economies in the consumption of engine fuel various methods are available, chief amongst which is the mixing of a cheaper fuel with the petrol. Ordinary good quality paraffin one part, petrol three parts by volume, is one such mixture, and this can be used in most carburetters. Whether a greater proportion of paraffin can be used without fouling the sparking plugs and valves, and making starting difficult, can only be settled by trial in individual cases. A half-and-half mixture of benzole and petrol is used with generally favourable results. Regarding "energizers," several have been suggested, but as these lack scientific testimony to their value it is impossible to implicitly recommend them. A definite claim has been made by some car owners that a small quantity of ordinary camphor dissolved in the petrol considerably improves the running, and they claim that more power with less throttle opening is obtainable, and the smoothness and flexibility of the engine are said to be markedly improved. The proportion found satisfactory is 1 oz. of camphor to each 5 gallons of petrol. The admixture of methylated ether in the proportion of 1 part to 10 parts of petrol is also favourably spoken of both for very easy starting and increased power.

List of Tools and Spare Parts for a Car

TOOLS.

Complete set of spanners adaptable to all principal nuts on the car, including sparking-plugs and wheel caps.

Reliable adjustable spanner. Small (cycle size) adjustable spanner, useful for tightening many of the smaller nuts. Flat and cutting pliers. Large gas pliers. Round-nosed pliers.

One large and one small screwdriver.

One large and one small hammer.

One flat file. One half-round file. One platinum contact file.

One knife-edge file. One each small square and round files.

Small portable vice to clamp on to step of car.

One wheel drawer, for removing non-detachable wheels from axle.

One pin driver. Cold chisel.

Metal saw in frame. Valve spring remover.

Small soldering outfit complete, with spirit lamp.

SPARE PARTS.

Complete set of engine valves, springs, and cottars.

Complete set of piston rings. Spring for clutch.

One leather or asbestos cover to re-face clutch (unless the clutch is metal-to-metal).

Set of sparking-plugs and washers.

Complete set of washers for joints on engine.

Magneto parts, such as platinum-tipped screw, carbon brushes, and springs. (Complete sets of these are sold in a case).

A spare armature is advisable when the car is taken abroad, unless the makers have an agency convenient.

USEFUL SUNDRIES.

Several yards of soft copper wire, Nos. 12, 16 and 20 gauge.

Asbestos sheeting 1-16th thick.

Fibre sheeting 1-32nd thick. Asbestos string.

Finest flour-emery and crocus powder for grinding-in valves.

Piece of "FF" emery-cloth.

Length of magneto cable.

Length of adhesive insulating tape.

Supply of calcium carbide in air-tight case for acetylene generator, or Spare bulbs (if electric light).

Spare dynamo belt.

Lubricating oil in can with long spout.

Paraffin oil and injector. Cleaning cloths (not waste).

Grease gun.

Gearbox lubricant. Stauffer grease.

Graphite lubricant for valve stems and screw threads.

Clutch lubricant (for metal clutches). Collan oil for clutch leather.

If oil lamps are fitted, spare wicks. Safety matches.

Petrol strainer and funnel.

Set of clips for water circulation joints.

Spare fan belt and fasteners.

Spare piece of rubber tube for water circulation connection.

Compression gauge.

Set of decarbonizing tools.

TYRE DETAILS.

Small vulcanizer. One inflator, preferably double-acting type.

Two spare tubes, with valves. Complete repair outfit.

Preparation for filling up cuts in outer cover.

One tyre pressure gauge. One "gaiter."

Set of levers, including fork lever for replacing valve.

One lifting jack. Spare cover (advisable to have when on tour).

CHAPTER XV

Formulæ, Tables, Explanations of Technical Terms

Properties of Material, etc.

Horse-power.—This nowadays has no relation whatever to the power developed by a horse—but is an unscientific way of defining power. In the days of Watt and other early engineers (of the 18th century) the work in ft. lbs. capable of being done by an average draught horse was taken as the unit of work. A motor rated at 1 horse-power is capable of doing 1 *mechanical unit of work*, which is equal to the power expended in lifting a weight of 33,000 lb. through a height of 1 foot in 1 minute of time. The French horse-power equals 32,549 foot pounds, and is thus less than the English standard.

"*Brake*" *horse-power* (abbrev. B.H.P.) is the power available at the driving shaft of the motor, such as could be determined by making a power absorption test by means of a brake type of dynamometer.

"*Actual*" *horse-power* is the amount of power that would be available if there were none absorbed by friction within the motor itself, and the total energy of the explosion was transmitted without friction or other losses to the motor shaft.

"*Indicated*" *horse-power* (abbrev. I.H.P.) is measured by taking an indicator diagram which shows the pressure of the explosion in pounds per square inch. For high-speed motors an optical device is used which plots out the pressure line on a photographic plate. From this the mean effective pressure during the stroke can be calculated.

Knowing the factors—Length of piston stroke in feet = S; diameter of cylinder (inches) = D; number of revolutions per minute = N; and mean explosion pressure per square inch on the piston = P—it is possible to calculate the:—I.H.P. = $.0000119\ D^2PNS$.

Mechanical efficiency is the ratio between the indicated h.p. and the h.p. available for useful work at the engine shaft, or if it refers to a machine or transmission system it is the output expressed in terms of the input of power.

Thermal efficiency of an engine equals the heat in British thermal units converted into work divided by the heat available × 100.

The bore and stroke of a motor (i.e., the cylinders) are, usually, expressed in millimetres, a more scientific unit of measurement than fractions of an inch—1 millimetre may be taken as equivalent to 1-25th part of an inch when moderate accuracy is required. The bore of a cylinder is the measurement across the circular space in which the piston moves. It is another way of expressing the internal diameter of the cylinder. The *stroke* is the length of the path through which the piston moves in the cylinder, and is equal to the diameter of the circle made by the crankpin centre.

Compression.—This usually refers to the compression of the explosive mixture drawn into the cylinder on the inlet stroke, which is subjected to a compression effect on the following stroke. The charge is forced into a space about one-fifth the volume or space of that occupied by it on the inlet stroke, and which gives 80 lb. to 90 lb. compression per square inch.

Otto "cycle" or four-stroke "cycle" is an expression used in connection with petrol, gas, or oil motors. The power is developed during a complete cycle of four strokes.

Internal-combustion engine.—Any type of engine in which the energy is developed directly from the fuel within the working cylinder. In a steam engine the energy is developed in the boiler separate from the engine in a less direct manner. All gas, oil, and petrol engines are internal-combustion.

Gear ratio.—The number of revolutions of the engine made for one revolution of the road wheels—this depending on which "speed" or gear is in use. Thus a top speed gear ratio may be 4 to 1, i.e., four revolutions of the engine to one of the road wheels.

British thermal unit, or B.T.U.—The amount of heat required to raise the temperature of 1 lb. of water 1 degree Fahr. (at its maximum density, which is at 39.1 degrees Fahr.). This expression is much referred to in the study of the value of various fuels for engines. It is often stated that a given fuel has a value of so many British thermal units; thus petrol ranges about 20,000 B.T.U. per lb.

Mechanical equivalent of heat.—This is represented by the number 778, which is the number of foot-pounds of work mechanically equivalent to one British thermal unit.

Specific gravity.—The ratio of the weight of any given liquid to the weight of an equal volume of distilled water at 60 degrees Fahr. Water is represented by 1, or unity. Petrol, bulk for bulk, is considerably lighter than water.

Flash point.—The temperature at which any oil or spirit heated in an open vessel begins to give off enough inflammable vapour to flash momentarily when a flame is brought into contact with it.

Calorific value.—This term is used with reference to various fuels, such as petrol, benzol, paraffin, etc., and represents the effective heating power per lb. in terms of British thermal units.

Notes on Constructive Materials used in Motorcars

Steel.—Special varieties are used throughout the chassis. Very little of the ordinary "mild" steel finds employment. The special steels used, often termed alloy-steels, contain a certain proportion of other metals or elements, such as chromium, nickel, vanadium, manganese, or silicon. These alloy-steels are far superior in strength to the commercial "mild" and low carbon steels, so that a very considerable reduction in weight is possible without lessening the strength and durability of the parts made from them, such as gear wheels, crankshafts, axles, frames, etc. Pistons of pressed steel are now much used. Magnet steel contains tungsten and other elements in small proportions. Dynamo magnets are now made of very soft steel castings instead of iron.

Iron.—Chiefly used for engine cylinders and pistons in the form of fine-grained cast-iron. In a few instances certain small parts, such as brackets, may be made of malleable or annealed iron casting: the annealing process eliminates the brittleness of the metal.

Phosphor-bronze.—Largely used for engine bearings. An alloy mainly consisting of copper and small proportions of tin, lead and phosphorus, the proportion of the latter being very small. It is a very tough, hard-wearing alloy.

White metal or anti-friction metal.—An easily fusible alloy of lead, antimony, and tin used for "lining" or re-metalling bearings.

Aluminium.—This metal, the chief characteristic of which is its lightness, is not generally used in its pure state, but is alloyed with a small proportion of zinc; sometimes, for special requirements, a small quantity

of copper and manganese are added. It is used for gearboxes, crank-cases, axle casings, etc. For dashboards, body panels, and similar parts ordinary commercial aluminium is often employed.

Manganese bronze.—Composed of copper, zinc and manganese. It makes very strong and tough castings. Forged front axles of this alloy are used on some American cars.

Platinum.—This very expensive metal (price ranging from £7 to £8 per oz., according to the market) is exclusively used for the contacts of the magneto. It is practically infusible (it has a very high melting point) and non-corrodible, and thus effectively resists the burning and oxidizing action of the electric spark. It is also used for the "leading in" wires of the electric bulbs used for car lighting, as it is the only metal that can be perfectly sealed into glass. Sparking-plug electrodes are, in a few instances, also made of it.

Nickel.—Used in the form of an alloy with steel, viz., nickel-steel. For exhaust valves a high percentage (20 to 25) nickel-steel is the most suitable material, as it effectively resists the intense heat and oxidizing action of the exhaust gases. Nickel is now the standard material for sparking-plug electrodes for the same reason.

Rubber.—For tyre construction rubber supplies come from various parts of the world. Amongst the finest grades is the well-known "Para" or Brazil rubber. South American rubber, generally, is considered very good, but excellent supplies now come from Borneo, India, Ceylon, Federated Malay States, and, in fact, many other tropical lands. Pure rubber lacks certain important physical characteristics indispensable for tyres, such as stability under change of temperature. Pure rubber becomes soft under the influence of heat, and hard and brittle when subjected to cold. The process of vulcanization renders the rubber proof against heat and cold, and also renders it tough and resilient, so as to possess "life" and vibration-absorbing properties.

Timber.—A considerable variety of timber enters into motorcar construction. Artillery wood wheels are usually built up of ash felloes, and oak spokes and hub. For body construction, the woods mainly employed are ash, birch and mahogany.

Carbon.—One of the well-known non-metallic elements. As it is an excellent conductor of electricity, and works well as a contact medium in conjunction with copper or brass, it is, therefore, largely used for the brushes of the magneto, and also for the brushes of car-lighting dynamos. Carbon in its natural form of graphite is used as a lubricant for gearing. It is generally mixed with grease, and is supplied ready prepared by lubricant manufacturers.

Celluloid.—This is a chemically-manufactured product, made from a basis of cotton or similar organic material, and used for a large number of auxiliary purposes, such as hood panels, windscreens, covering of steering wheels, accumulator boxes, etc. Its transparency and flexibility are its chief characteristics. Non-inflammable celluloid is now made for windscreens.

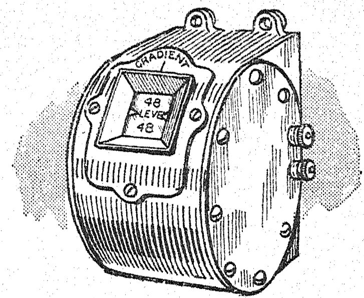
Asbestos.—The material is of mineral origin (large quantities come from Canada). In its natural state it is fibrous and somewhat brittle. As it resists great heat, it finds considerable application in motor work for engine jointing in the form of packing washers (of copper sheet and asbestos). Asbestos cord is used for covering exhaust pipes where these pass through woodwork, etc. Worked up into a fabric with brass wire, it is largely used for brake-block linings and clutch covering, as it cannot be burnt out by excessive friction.

Vulcanite (or ebonite).—A composition of rubber and sulphur. It is an excellent electrical insulating material, although not capable of

withstanding heat. Switches, insulators and similar fitments are made from it, also accumulator cases.

Vulcanized fibre.—This is a tough, durable, manufactured material, used for many auxiliary purposes. It has high electrical insulating properties, although one of its drawbacks is that it absorbs moisture to some extent. As it resists heat much better than vulcanite, it is often used in the form of tubing to carry and protect the wires from the magneto to the plugs. Another use for this material is in the construction of timing gearwheels, in which it is built up with bronze, to give it mechanical support. The interior part of the teeth being of fibre, gives quieter running than solid metal pinions. It was formerly much used for clutch surfaces where the clutch could be run in oil. It is still used for the automatic clutch on some types of car-lighting dynamos.

The Gradometer is a compact instrument which is attached to the dashboard and automatically indicates a falling or rising gradient.



Gradients

A grade of	1 in 5	equals	20	per cent.,	or angle of	11° 19′
,, ,,	1 in 6	,,	17	,,	,,	9° 26′
,, ,,	1 in 7	,,	14	,,	,,	8° 09′
,, ,,	1 in 8	,,	12½	,,	,,	7° 08′
,, ,,	1 in 9	,,	11	,,	,,	6° 17′
,, ,,	1 in 10	,,	10	,,	,,	5° 43′
,, ,,	1 in 11	,,	9	,,	,,	5° 11′
,, ,,	1 in 12	,,	8	,,	,,	4° 46′
,, ,,	1 in 13	,,	7¾	,,	,,	4° 24′
,, ,,	1 in 14	,,	7	,,	,,	4° 05′
,, ,,	1 in 15	,,	6½	,,	,,	3° 49′
,, ,,	1 in 16	,,	6¼	,,	,,	3° 35′
,, ,,	1 in 17	,,	6	,,	,,	3° 22′
,, ,,	1 in 18	,,	5½	,,	,,	3° 11′
,, ,,	1 in 19	,,	5	,,	,,	3° 00′
,, ,,	1 in 20	,,	5	,,	,,	2° 52′

Tyre Sizes: Equivalent in Millimetres and Inches

26	inches	=	650	millimetres	2¼	inches	=	60	millimetres
28	,,	=	700	,,	2½	,,	=	65	,,
30	,,	=	750	,,	3	,,	=	80	,,
32	,,	=	800	,,	3¼	,,	=	85	,,
33	,,	=	840	,,	3½	,,	=	90	,,
34	,,	=	870	,,	4	,,	=	100	,,
35	,,	=	880	,,	4½	,,	=	105	,,
36	,,	=	910	,,	5	,,	=	120	,,
40	,,	=	1010	,,	5½	,,	=	135	,,
					6	,,	=	150	,,
					7	,,	=	175	,,

(Nominal sizes for comparison only.)—See makers' lists.

Conversion of Metric into English Measure

1 millimetre is exactly .03937 of an inch.
1 millimetre is approximately 1-25th of an inch (25 mm. = .9843in.).
1 centimetre is exactly .3937 of an inch.
1 centimetre is approximately 13-32nds of an inch.
1 metre is exactly 1.0936 yards, approximately $39\frac{1}{4}$ inches.
1 kilometre is 1,000 metres and equals .6213 mile.
1 kilogramme (1,000 grams) is equal to 2.21 lbs.
1 litre is equal to 1.76 pints.
1 U.S.A. gallon is equal to .832 Imperial gallon.
To convert metres to yards multiply by 70 and divide by 64.
To convert kilometrés to miles (approximately) multiply by 5 and divide by 8; or see conversion chart. (Page 246).
To convert litres to pints, multiply by 88 and divide by 50.
To convert grams to ounces multiply by 20 and divide by 567.
To find the cubic contents of a motor cylinder, square the bore (dia.), multiply by .7854, and multiply result by the stroke.
To convert inches to centimetres multiply by 2.54.
To convert cubic inches to cubic centimetres multiply by 16.39.
To convert cubic metres to cubic feet multiply by 35.32.
To convert sq. centimetres to sq. inches multiply by .155.
To convert gallons of water to lbs. multiply by 10.
Temperature conversion formula :—
Centigrade to Fahrenheit ... ... $°F = \frac{9}{5} C° + 32$
Fahrenheit to Centigrade ... ... $°C = \frac{5}{9} (F° - 32)$
Atmospheric pressure equals 14.7 lbs. per square inch.
A halfpenny is equal to 1 inch diameter or 25 millimetres.
1 cubic ft. of air at 62°F. = 1.217 ozs.
1 lb. of air at 62°F. = 13.141 cubic ft.
1 volume of petrol yields (by calculation) 276 volumes of petrol vapour.

Table of Cylinder Bores and Strokes in Millimetres and Inches

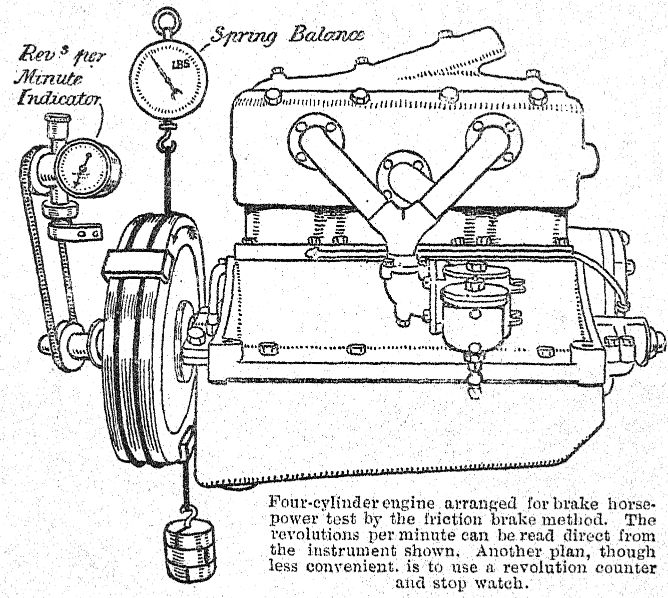
The following figures are approximate, and intended only as a rough guide for comparison. For accurate measurements a sliding calliper with inches and metric scales should be used. A scale for direct comparison is given further on in this chapter.

A Cylinder	Equals in Inches
2 by 100 millimetres ...	$2\frac{7}{16}$ by $3\frac{15}{16}$
5 ,, 120 ,, ...	$2\frac{9}{16}$,, $4\frac{3}{4}$
66 ,, 70 ,, ...	$2\frac{9}{16}$,, $2\frac{3}{4}$
67 ,, 70 ,, ...	$2\frac{5}{8}$,, $2\frac{3}{4}$
67 ,, 73 ,, ...	$2\frac{5}{8}$,, $2\frac{7}{8}$
67 ,, 77 ,, ...	$2\frac{5}{8}$,, 3
70 ,, 70 ,, ...	$2\frac{3}{4}$,, $2\frac{3}{4}$
70 ,, 73 ,, ...	$2\frac{3}{4}$,, $2\frac{7}{8}$
70 ,, 77 ,, ...	$2\frac{3}{4}$,, 3
72 ,, 77 ,, ...	$2\frac{13}{16}$,, 3
73 ,, 73 ,, ...	$2\frac{7}{8}$,, $2\frac{7}{8}$
73 ,, 80 ,, ...	$2\frac{7}{8}$,, $3\frac{1}{8}$
77 ,, 77 ,, ...	3 ,, 3
77 ,, 80 ,, ...	3 ,, $3\frac{1}{8}$
77 ,, 83 ,, ...	3 ,, $3\frac{1}{4}$
78 ,, 78 ,, ...	$3\frac{1}{16}$,, $3\frac{1}{16}$
80 ,, 80 ,, ...	$3\frac{1}{8}$,, $3\frac{1}{8}$
80 ,, 86 ,, ...	$3\frac{1}{8}$,, $3\frac{3}{8}$
83 ,, 83 ,, ...	$3\frac{1}{4}$,, $3\frac{1}{4}$
88 ,, 86 ,, ...	$3\frac{1}{4}$,, $3\frac{3}{8}$

A Cylinder	Equals in Inches
86 by 86 millimetres ...	$3\frac{3}{8}$ by $3\frac{3}{8}$
84 ,, 90 ,, ...	$3\frac{5}{16}$,, $3\frac{9}{16}$
90 ,, 90 ,, ...	$3\frac{9}{16}$,, $3\frac{9}{16}$
90 ,, 110 ,, ...	$3\frac{9}{16}$,, $4\frac{5}{16}$
95 ,, 115 ,, ...	$3\frac{3}{4}$,, $4\frac{9}{16}$
100 ,, 115 ,, ...	$3\frac{15}{16}$,, $4\frac{9}{16}$
105 ,, 118 ,, ...	$4\frac{1}{8}$,, $4\frac{5}{8}$
108 ,, 120 ,, ...	$4\frac{1}{4}$,, $4\frac{3}{4}$
110 ,, 125 ,, ...	$4\frac{5}{16}$,, $4\frac{15}{16}$
112 ,, 128 ,, ...	$4\frac{7}{16}$,, $5\frac{1}{16}$
114 ,, 130 ,, ...	$4\frac{1}{2}$,, $5\frac{1}{8}$
116 ,, 134 ,, ...	$4\frac{9}{16}$,, $5\frac{5}{16}$
118 ,, 138 ,, ...	$4\frac{5}{8}$,, $5\frac{7}{16}$
120 ,, 140 ,, ...	$4\frac{3}{4}$,, $5\frac{1}{2}$
122 ,, 143 ,, ...	$4\frac{13}{16}$,, $5\frac{5}{8}$
124 ,, 146 ,, ...	$4\frac{7}{8}$,, $5\frac{3}{4}$
126 ,, 148 ,, ...	$4\frac{15}{16}$,, $5\frac{13}{16}$
128 ,, 150 ,, ...	$5\frac{1}{16}$,, $5\frac{15}{16}$
130 ,, 152 ,, ...	$5\frac{1}{8}$,, 6
140 ,, 160 ,, ...	$5\frac{1}{2}$,, $6\frac{3}{8}$

Power, Momentum and Energy

The power unit used in motor work is *a standard rate* of doing mechanical work, equal to 33,000 lb. mass (or weight) raised through a height of 1 foot in 1 minute; or if we move 16,500 lb. through 2 feet or any proportionate ratio which multiplied together equals 33,000 in the same time it is also equal to working at the rate of 1 horse-power. This means that, theoretically, if the speed of a motorcar engine could always be kept constant, and thus be giving uniform power, this power could be utilised to move any load up any gradient by taking a proportionately longer time to do it, providing that the car had a perfect all-speed gear. This principle is, as far as possible, realised by the change-speed gear of a car which gives a range of three or four speeds. Wind resistance increases in proportion to the "square" of the speed: thus at 20 miles per hour it is four times what it is at 10 miles, and at 30 miles per hour nine times, and so on.



Four-cylinder engine arranged for brake horse-power test by the friction brake method. The revolutions per minute can be read direct from the instrument shown. Another plan, though less convenient, is to use a revolution counter and stop watch.

Comparison of Power from Large v. Small Cylinders and at High v. Low Speeds

A given amount of power can be developed in cylinders of either large or small diameter. Thus there is the example of the gas engine. To obtain, for example, 10 h.p. from this type of engine a very large cylinder and low speed of revolutions would be employed with a maximum speed of perhaps 250 revolutions per minute. A modern 10 h.p. car engine on the other hand has four very small cylinders, but a high speed of revolutions, say, 1500 to 2000 per minute. The individual power impulses are very much weaker than those of the large slow speed engine, and consequently its parts can be made so much lighter and smaller, as the shocks and stresses that have to be sustained are proportionately much less.

The measurement of the brake horse-power (B.H.P.) of motors may be made by a simple "brake" test, as follows:—A rope is passed once round the flywheel of the motor, and one end secured to a spring balance which is hooked to a support just above the flywheel. To the other end of the rope is attached a scale pan, into which weights can be placed. Knowing the flywheel diameter, and the speed, and the weight that can be put into the scale pan, which is *pulling against the direction* of rotation, the horse-power can be calculated. Arranged as a formula it works out thus:—

$$\text{Brake horse-power} = \frac{(W_1 - W_2) \times \frac{22}{7} \times N \times D}{33{,}000}$$

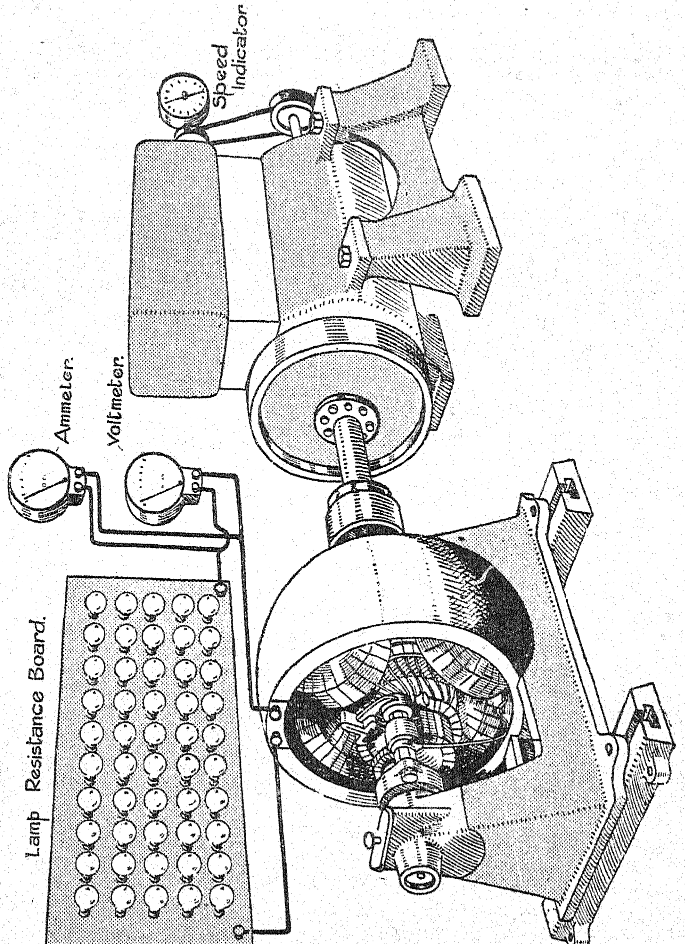
W_2 is the reading on the spring balance, and this is subtracted from the weights W_1, hanging on the end of the rope. N is the number of revolutions of the pulley per minute, and D diameter of flywheel *(plus thickness of rope)* in feet. The speed is measured by an ordinary speed counter and stop-watch. The rope should be held on the flywheel by guide pieces, and the interior of the flywheel cooled by water.

Test Bench Arrangements

The method of testing h.p. by the brake apparatus is one considerably used in the motor test workshop. In practised hands the test can be made rapidly, and for ordinary practical purposes it has an ample degree of accuracy, such as for determining whether a range of engines of the same type reach a specified standard of power. In the workshop arrangement the rope brake is not often used, except where a test has to be improvised. Unless it be carefully handled there is some risk of accident from the weights being flung from the wheel. It is, therefore, usual to provide in place of the ropes a couple of brake blocks cut to the correct curvature of the flywheel or pulley. An arm is attached to one of the blocks which are loosely connected together by bolts, so that the brake can be adjusted to the flywheel, the bolts then being screwed up to just bring the blocks into contact. On the end of the arm the weights are placed, allowance being made for the length of the arm in the calculation.

Electrical Test

There is an electrical method adopted by some makers as being more accurate than the brake test. The method is as follows:—The engine is belted or (preferably) coupled direct to a dynamo machine. Connected up with the dynamo are two specially accurate electrical measuring instruments, one a voltmeter and the other an amperemeter. The current which the dynamo produces when driven is used up by either a group of glow lamps or a set of wire or liquid resistances. The amount of work the dynamo will do, such as lighting lamps, etc., depends on the power put into it from the petrol motor. It is easy to convert electrical power units into mechanical units. Thus: Amperes × volts = watts, and there are 746 watts to a horse-power, so that by simply taking the readings of the voltmeter and ammeter the amount of power the dynamo is giving out is at once calculated. The dynamo, of course, does not transform the whole of the power put into it into electricity but it may transform somewhere about 90 per cent. of it. Certain mechanical and electrical losses occur in the dynamo, but these are calculated beforehand. Hence, knowing exactly how much of the power put into the dynamo is lost or wasted, and the maximum amount given out, the two sums added



ILLUSTRATING THE SIMPLEST ELECTRICAL METHOD OF MEASURING BRAKE HORSE POWER.

The engine is directly coupled to a continuous current dynamo, the current generated at maximum speed being absorbed by a bank of lamps or other adjustable form of resistance. The "watts" generated are calculated from the ammeter and voltmeter readings. Allowance is made in the calculation for the fixed losses of power in the dynamo, the over-all efficiency of which is determined beforehand. More complicated modifications of the method are sometimes used.

together will give the power actually produced by the motor. A very convenient form of dynamometer consists of a fan with two adjustable blades, which can be set to certain positions on graduated arms. At a given speed the fan absorbs a definite amount of brake horse-power. The fan is coupled direct to the shaft of motor to be tested. Power testing apparatus is now used to a considerable extent, by means of which the power available at the road wheels of a car under running conditions may be measured. The dynamometer acts upon large drums, upon which the driving wheels of the car are mounted. The mechanical efficiency of various systems of transmission can also be accurately determined by this means.

Horse-power Formulæ

The following give reasonably accurate results:—(1) Cylinder capacity in litres × maximum revolutions per minute × .0064 = brake-horse-power, or (2) Bore in inches squared × stroke × number of cylinders × revolutions per minute.

$$\frac{\text{Bore in inches squared} \times \text{stroke} \times \text{number of cylinders} \times \text{revolutions per minute}}{12{,}000}$$

Another is:—

$$\frac{(\text{Bore} + \text{Stroke in millimetres})^2}{6{,}500} \times \text{number of cylinders} = \text{horse-power.}$$

I.A.E. h.p. formula:—

$$\frac{(\text{Bore} + \text{Stroke}) \text{ in mm.} \times (\text{Bore}-29.97)}{1433.} \times \text{number of cylinders.}$$

Power Required to Propel a Car on Level Roads

This is determined by the formula $\dfrac{F \times W \times D}{33{,}000\ T}$

F = Tractive force in pounds per ton (may be taken as 50 lb. per ton).
W = Total weight propelled in tons.
D = Distance travelled in feet.
T = Time in minutes.

Power Required to Propel a Car up a Hill

Formula: $\dfrac{\dfrac{D}{H} W}{33{,}000\ T}$

D = Total distance travelled in feet.
H = Distance travelled in feet for a vertical rise of one foot.
W = Total weight propelled.
T = Time in minutes.

Rating Formula of the Society of Motor Manufacturers and Traders

$$\text{B.H.P.} = 0.197d\,(d-1)\,(R+2)\,N$$
$$= \frac{d\,(d-1)\,(R+2)\,N}{5}$$

d = Diameter of cylinder in inches.

R = Ratio of bore to stroke = $\dfrac{\text{Stroke.}}{\text{Bore}}$

N = Number of cylinders.

S.M.M.T. Rating for Accumulators

Ampere Hours = Actual capacity at constant discharge. Approximate capacity at intermittent discharge.

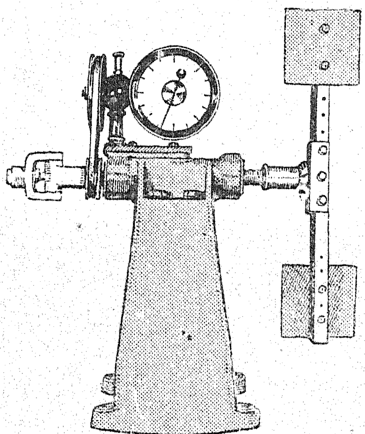
It is important to keep in mind the fact that the capacity a cell shows at intermittent discharge is always much higher than the capacity at constant discharge, and the lower the discharge rate the higher the capacity tends to become, but it cannot be more than 80 per cent. or so of the net ampere-hours put into the cell in charging.

B.H.P. Tests by Accelerometer

This instrument is now much used for making road tests of cars and determining the hill-climbing capabilities and acceleration on the various gears. By using this instrument in conjunction with an accurate speedometer the B.H.P. developed by a car at a given speed can be determined. The formula used is:—

$$\text{B.H.P.} = \frac{\text{Speed in m.p.h.} \times R \times \text{weight of car in tons.}}{375}$$

R = resistance to motion in lbs. per ton. This factor can be read off on the accelerometer.



Air or fan brake dynamometer with speedometer used for obtaining approximate readings of h.p. developed.

Mechanical Efficiency of Gearing

The two systems of final drive now employed, i.e., bevel gear and worm gear, show a mechanical efficiency of well over 90 per cent. The highest figures recorded are 97 per cent., the gears being tested when new and under the most favourable conditions. In the course of normal usage this high efficiency would fall off to some extent, although with a well-designed worm gear the amount is less than with a bevel, but 90 per cent. efficiency should be maintained for a top gear drive. The overall efficiency on the usual three lower gears is lower than the top gear, as there are unavoidable losses due to the intermediate pinion friction.

It is difficult to give any standard figures for these, as owing to the wide range of gearbox design the losses would be smaller in some cases than others.

Rating Formula (Royal Automobile Club)

$$\frac{\text{Bore (squared)} \times \text{number of cylinders.}}{2.5}$$

Result equals power at engine flywheel. For power at road wheels divide by 3 (cylinder dimensions in inches). If taken in millimetres, divide by 1613 instead of 2.5, for power at flywheel.

As this formula does not take the stroke or rate of revolutions into calculation, it should not be regarded as a B.H.P. formula but simply as a ready means of comparison between engines of given bores and number of cylinders. A uniform piston speed of 1000 ft. per minute and a mean effective explosion pressure of 67.2 lb. per sq. in. are taken in the R.A.C. formula.

Hill-climbing Formulæ

The Royal Automobile Club system of handicapping cars of various powers and weights in hill-climbing competitions so that all shall have an equal chance of winning is based on the principle of determining the mechanical efficiency relative to the horse-power determined from the h.p. rating $\frac{D^2 N}{3}$ The speed of a car on a hill depends on five factors:—

(*a*) Difference in height between starting and finishing point through which the car is raised; this is independent of length of hill.

(*b*) Rolling resistance which has to be overcome; this depends on length of hill, and not on height.

(*c*) Air resistance opposing car.

(*d*) Power available at road wheels.

(*e*) Running weight of car.

These factors, for purposes of calculation, may be expressed thus:—

h = Height in feet.
w = Weight in pounds.
t = Time in minutes.
L = Length of course in feet.
P = Air pressure per square foot in pounds.
a = Area in square feet.
V = Speed in miles per hour.
r = Factor for rolling resistance.

The horse-power necessary to overcome factors (*a*), (*b*), and (*c*) have now to be determined thus:—

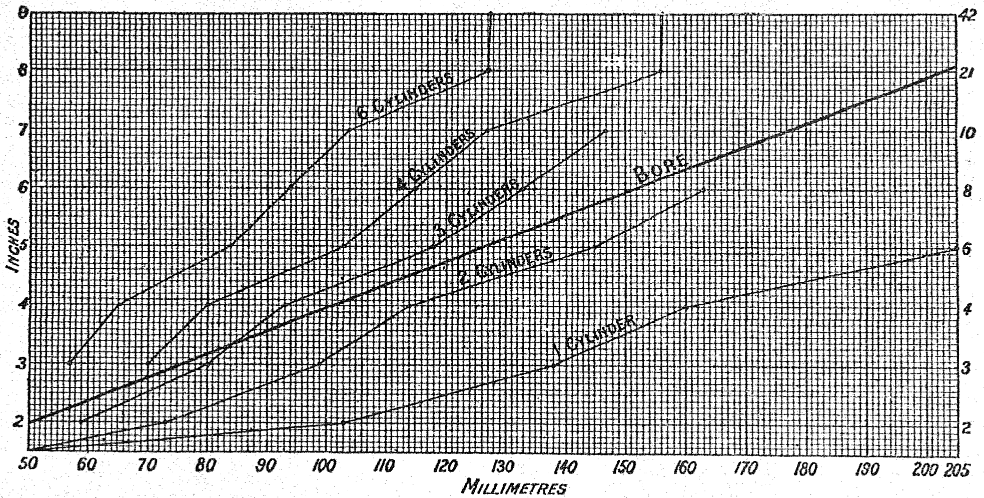
$$(a)\ \text{H.P.} = \frac{h \times w}{33{,}000 \times t} \quad (b)\ \text{H.P.} = \frac{L \times r}{33{,}000 \times t} \quad (c)\ \text{H.P.} = \frac{L \times Pa}{33{,}000 \times t}$$

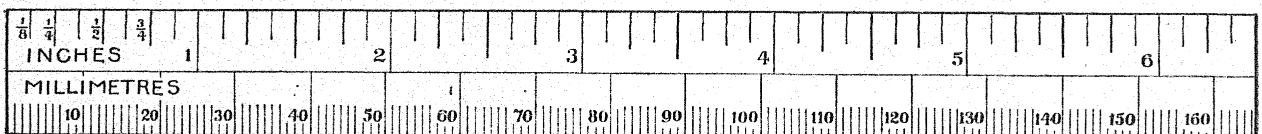
Factor (*d*) is taken as 66 per cent., which is a minimum efficiency for the transmission; factor (r) is taken as 40 lb. per ton, a very low allowance for an average road surface; factor (P) air resistance is $.0017V^2$, where V is miles per hour.

Having found the horse-power used in formulæ (*a*), (*b*), and (*c*), these added together give the total power used, so that a ratio is obtained between the calculated B.H.P. $\frac{D^2 N}{3}$, and the power converted into useful work in propelling the car up the hill. In an actual example it was found that the power used to overcome (*a*) was 24.68, (*b*) 5.32, and (*c*) 2.63, total 32.63 h.p. The power of engine obtained from $\frac{D^2 N}{3}$ was 47.5, therefore the ratio is 32.63 to 47.5, giving an efficiency of 68.7 per cent.

A Motor Tax Calculator

To find the tax payable, trace the size of the bore from either the inches or mm. scale to the line marked "bore;" follow the vertical line from this point to its intersection of the chart for the number of cylinders, and read the tax at end of horizontal line passing through the black dot above this intersection. Thus, to find the tax payable for a four-cylinder engine of 3·7 in. (or 94 mm.) bore, trace the line from 3·7 on the inch scale (or 94 on the mm. scale) to the line marked "bore;" follow the vertical line from this point to its intersection of the four-cylinder chart, and read six guineas at the end of the horizontal line which passes through the dot above this intersection.





Useful Conversion Scale. Inches to Millimetres.

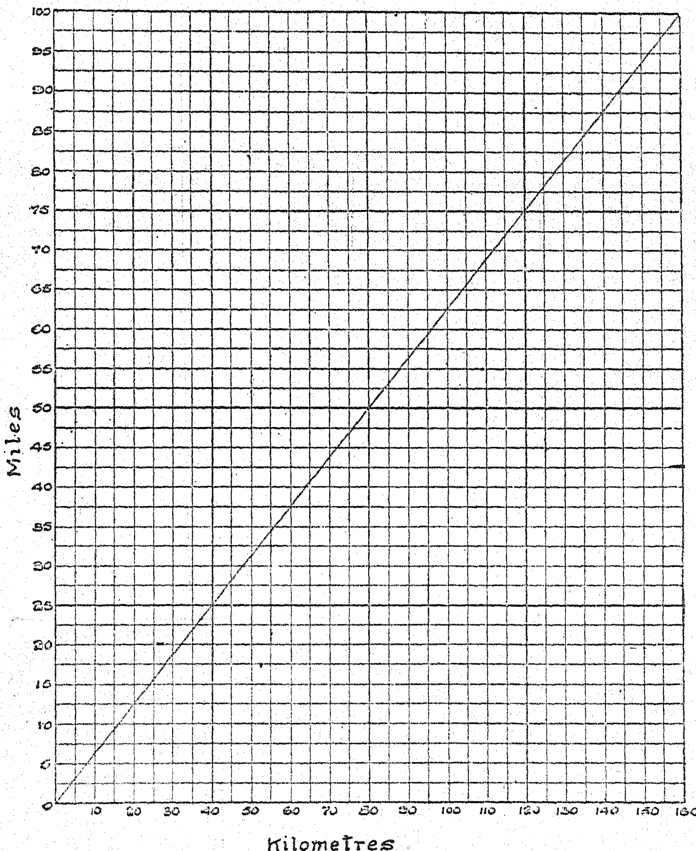
To Convert Kilometre-Seconds into Miles per Hour

A Kilometre in SEC.	Miles per hour.	A Kilometre in MIN.	SEC.	Miles per hour.
16	139.70	0	55	40.65
18	124.26	0	56	39.93
20	111.83	0	57	39.23
21	106.50	0	58	38.55
22	101.66	0	59	37.89
23	97.24	1	0	37.26
24	93.19	1	1	36.65
25	89.54	1	2	36.06
26	86.02	1	3	35.49
27	82.83	1	4	34.93
28	78.88	1	5	34.40
30	74.53	1	6	33.88
31	72.13	1	7	33.37
32	69.87	1	8	32.88
33	67.76	1	9	32.41
34	65.76	1	10	31.94
35	63.88	1	11	31.49
36	62.11	1	12	31.05
37	60.43	1	13	30.63
38	58.85	1	14	30.21
39	57.33	1	15	29.81
40	55.90	1	16	29.42
41	54.53	1	17	29.03
42	53.24	1	18	28.66
43	52.00	1	19	28.30
44	50.82	1	20	27.95
45	49.69	1	21	27.60
46	48.61	1	22	27.26
47	47.57	1	23	26.94
48	46.58	1	24	26.62
49	45.63	1	25	26.30
50	44.72	1	26	26.00
51	43.84	1	27	25.70
52	43.00	1	28	25.41
53	42.19	1	29	25.12
54	41·40	1	30	24.84

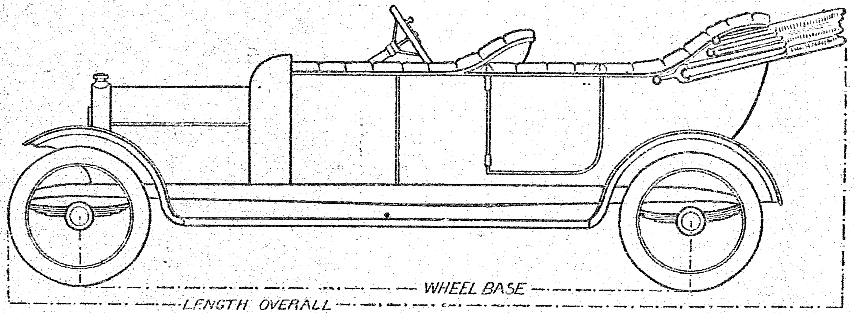
Speed in Miles per Hour

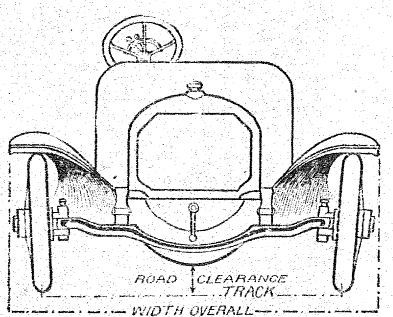
1 Mile in = Min. Sec.	Miles per Hour.	2 Miles in = Min. Sec.	Miles per Hour.	3 Miles in = Min. Sec.	Miles per Hour.	4 Miles in = Min. Sec.	Miles per Hour.	5 Miles in = Min. Sec.	Miles per Hour.
2 39	22·6	5 18	22·6	7 57	22·6	10 36	22·6	13 15	22·6
2 42	22·2	5 24	22·2	8 6	22·2	10 48	22·2	13 30	22·2
2 45	21·8	5 30	21·8	8 15	21·8	11 0	21·8	13 45	21·8
2 48	21·4	5 36	21·4	8 24	21·4	11 12	21·4	14 0	21·4
2 51	21·1	5 42	21·1	8 33	21·1	11 24	21·1	14 15	21·1
2 54	20·7	5 48	20·7	8 42	20·7	11 36	20·7	14 30	20 7
2 57	20 3	5 54	20·3	8 51	20·3	11 48	20·3	14 45	20·3
3 0	20	6 0	20	9 0	20	12 0	20	15 0	20
3 6	19·4	6 12	19·4	9 18	19·4	12 24	19·4	15 30	19·4
3 12	18·8	6 24	18·8	9 36	18·8	12 48	18·8	16 0	18·8
3 18	18·2	6 36	18·2	9 54	18·2	13 12	18·2	16 30	18·2
3 24	17·7	6 48	17·7	10 12	17·7	13 36	17·7	17 0	17·7
3 30	17·1	7 0	17·1	10 30	17·1	14 0	17·1	17 30	17·1
3 36	16·7	7 12	16·7	10 48	16·7	14 24	16·7	18 0	16·7
3 42	16·2	7 24	16·2	11 6	16·2	14 48	16·2	18 30	16·2
3 48	15·7	7 36	15·7	11 24	15·7	15 12	15·7	19 0	15·7
3 54	15·4	7 48	15·4	11 42	15·4	15 36	15·4	19 30	15·4
4 0	15	8 0	15	12 0	15	16 0	15	20 0	15
4 6	14·6	8 12	14·6	12 18	14·6	16 24	14·6	20 30	14·6
4 12	14·3	8 24	14·3	12 36	14·3	16 48	14·3	21 0	14·3
4 18	13·9	8 36	13·9	12 54	13·9	17 12	13·9	21 30	13·9

Miles to Kilometres Conversion Chart



This chart provides a quick method of finding with sufficient accuracy for practical purposes the relation between miles and kilometres from 0 to 100 miles and 0 to 160 kilometres. As an example: if it is desired to find the equivalent distance of 60 miles in kilometres, take the horizontal line opposite 60 to the point where the diagonal line crosses it, which is just in advance of a vertical line, reading 95 kilometres; the difference may be estimated at 1 kilometre or a little over. This would give just over 96 kilometres. By exact calculation, 60 miles is equal to 96·558 kilometres.





Diagrams to explain how the usual dimensions of a car are measured. It should be mentioned that the road clearance depends on the vertical distance of the lowest part of the chassis from the road surface, generally this is the underscreen, but in some instances it may be the differential gear case.

CHAPTER XVI

Touring

Through the medium of the motorcar, touring on the Continent is brought readily within the reach of those who, a few years ago, would have regarded a Continental trip of the rail-cum-coach order as a tremendous undertaking. The credit of this is largely due to the Royal Automobile Club as the pioneer of the facilities for taking a car into Continental countries and to the other associations—the Automobile Association and the Motor Union—that have followed up the good work. The effect has been phenomenal, for France, in particular, is a most popular touring ground with British motorists, the R.A.C. alone having issued some thousands of sets of French triptyque papers during the few years that the touring department has been able to provide this ideal method of complying with the requirements of the French Customs. The great straight roads of France, free as they are, for the most part, from the narrow "bottle necks" and dangerous curves, the forks where the less important road is frequently wider than the through main roads and the other puzzles characteristic of the roads in this country, have always appealed to the motorist who does not care to merely dawdle on the way, although he who loves winding roads, and the more picturesque country generally to be found associated therewith, can find all that he wishes in the lesser-known areas.

Motoring Organizations and Foreign Touring

As it will doubtless be interesting to readers to know how easily one can, nowadays, take a car into France and to comply with the regulations, the following details have been obtained from the touring departments of the organizations making a speciality of this work. Touring advantages are open not only to members of the R.A.C., but to associate members and members of the associated clubs. The procedure is for a member to call upon or write to the touring department and ask for assistance in arranging a tour in France, for instance.

He receives three forms, on one of which he is asked to give such particulars of himself and his car as will be required by the French authorities for the issue of his licence and his *permis de circulation.* By thus anticipating every requirement of the authorities, every possible chance of delay in the examination and issue of the documents is prevented. Another form is for such particulars of the car as are required by the Customs, and attached to it is a schedule giving the Customs duties for each country and the basis upon which they are calculated. The third form gives the particulars of the rail and boat service on the route selected, with the fares for passengers and the charges for the car, and attached is an order to be filled up with particulars of the tickets required and information that will be required by the steamship officials. The tickets and Customs papers are issued at once by the Club, on receipt of the fares, car rate, and Customs deposit, and all that the tourists have then to do is to drive

to the port of departure and hand the car over to the steamship officials.

At the port of landing, the Club's agent meets the boat and, with all the particulars already in his hands, he will have arranged for the examining official to be present. The car will be inspected, which means that a superficial look over the car is given, with a view to ascertaining that it is safe to travel on the roads. A car with abnormal speed capabilities and with hopelessly defective brakes would probably be disqualified. The examination of the driver consists of a drive of about ten minutes' duration—quite sufficient to show that one is not totally ignorant of the control of the car.

The Most Convenient Routes to the Continent

These are (1) viâ Folkestone and Boulogne, a boat crossing each way each morning and afternoon and taking cars; (2) viâ Southampton and Havre, a boat crossing each way each night; and (3) viâ Newhaven and Dieppe. The last-named route is gradually improving in the details of its arrangements. The Folkestone route is the most popular because the South-Eastern and Chatham Railway have, from the first, instituted admirable arrangements for dealing with the cars expeditiously and carefully, each car being handled on a tray during shipment.

Customs Duties and French Licence Fees

A new law exacts a licence fee of 32 francs from each driver of (1) petrol-driven or (2) steam-driven cars. This licence holds good indefinitely and for all cars of the one type. Previously a licence would be obtained free or at a nominal cost of 1fr. 50c. or 2frs., but a fresh one had to be obtained for each car one drove. The examination fees, agency fees, and tips are all covered by one payment. The tips, which at one time used to be a formidable item for the unpiloted tourist, are all done away with, the R.A.C. agent paying them all and taking his fee from the above amounts.

The Customs deposit is paid to the Club in exchange for the Customs papers, the duty on cars entering France being, for cars weighing 500 to 2500 kilos (or a maximum of 49 cwt. 22 lb.), £2 0s. 8d. per cwt.; cars exceeding this weight pay £1 0s. 4d. per cwt., Germany £1 per cwt. or 12s. 6d. per cwt., according to whether the car is over or under 19¾ cwt., cars exceeding this weight pay 8s. per cwt., the greater the weight the lower the basis, and Austria £2 12s. per cwt. if the car does not exceed 36 cwt. For Italy £1 12s. per cwt., a sum of £24 has to be deposited on a car over 19¾ cwt. The car is weighed in running order, but luggage can be removed.

The deposits are held by the R.A.C. and are refunded on the production of a set of forms provided for each country, which have to be stamped by the Customs both on entering and leaving the country.

New Continental Touring Facilities

The R.A.C. and Automobile Association are now authorized to issue the International Customs booklet, known as the "Carnet," which enables its holder to tour in any of the following European countries:—Austria, Belgium, Denmark, France, Holland, Italy, Sweden and Switzerland. This document takes the place of separate triptyques for each country, and the holder has to pay a deposit of only one duty, viz., that of the country which has the highest duty amongst those for which it is available. The "Carnet," however, does not apply to Germany.

It is obvious that what has been sketched out as the course of action taken by the Royal Automobile Club on behalf of its members

must necessarily be the same for the Automobile Association and other organisations on behalf of their members respectively. The Automobile Association and Motor Union has, besides making the most complete Customs and examination arrangements, appointed a special representative, who is in attendance at Boulogne on the arrival of every steamer. Wearing a miniature A.A. badge, he takes charge of the arrangements, and is at the disposal of members for any reasonable need that they may have of his services.

The Rule of the Road in France is to keep to the right, the reverse of the English rule, and overtake vehicles on the left.

The legal speed limits are 19 miles (30 kiloms.) per hour in open country, and 12½ miles per hour in passing through towns and villages. Two front lights must be carried, one showing white and one showing green. A rear lamp must be carried on the left side of the number plate.

Official Regulations for Touring Abroad

Motorists who proceed to the Continent for a motor tour are now obliged to provide themselves with documents certifying the fitness of the vehicle and the competence of the driver. An Order in Council has been issued giving to the Local Government Board authority for carrying out the provision made by this country in accordance with the conditions and agreements in the International Convention. It is laid down that the Local Government Board may, under such conditions as they think fit, authorize one or more associations to perform the duties relating to the examination of the car and of the driver. So that, in so far as British motorists are concerned, the regulations create no difficulties, the various motoring organizations

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Reproduction of Official Form

SECOND SCHEDULE.
FORM A.

Number________________

MOTOR CAR (INTERNATIONAL CIRCULATION) ORDER, 1910.

CERTIFICATE OF FITNESS OF CAR.

This is to certify that the motorcar described hereunder has been examined and found to be fit for use on the highway in a Foreign Country.

Name of Owner of Car (in full)____________

Owner's home address____________

Index letter and registered number of car____________

Description of car (*e.g.*, motorcar, motorcycle, etc.)____________

Name of Manufacturer____________

Type of chassis or engine____________

Body of car: shape____________ colour____________ number of seats____________

Weight of car unladen (*in kilogrammes*).____________

Seal.

Signature.

____

being charged with the task of seeing that the regulations are complied with. Every certificate of fitness or of competence and every international travelling pass, which is issued when the certificates have been obtained, will be valid for a period of one year from the date of issue. The fees charged amount to one guinea, this being made up by three separate fees of 7s. each, two for certificates and one for the pass. The conditions which have to be fulfilled by motorcars to obtain the certificate of fitness are specified in a schedule appended to the Order, and are as follow:—(1) The machinery must be such as can be trusted to work efficiently and must be so designed as to prevent, as far as possible, all danger of fire or explosion, as not to frighten by its noise animals, whether ridden or driven, and as not to give rise to any other cause of danger to traffic or seriously to inconvenience by the emission of smoke or vapour any persons using the road. (2) The motorcar must be provided with the following: (*a*) A strong steering apparatus, which will allow the car to be turned readily and with certainty. (*b*) Two brakes, each independent of the other and adequate for its purpose. One at least of these brakes must be capable of acting rapidly and directly upon the wheels or upon brake-drums immovably fixed thereto. (*c*) A mechanism which is capable of preventing, even on steep gradients, any backward movement, if one of the brakes is not of itself sufficient for the purpose. Every motorcar whose weight unladen exceeds 350 kilo. (7 cwt.) must be so constructed that the driver can, from his seat, reverse the movement of the car by means of the driving power. (3) All the driving and steering apparatus must be so arranged that the driver can manipulate it with certainty, and, at the same time, have a clear view of the road. (4) Every motorcar must be provided with plates showing the name of the manufacturer of the chassis and the manufacturer's number, the horse-power of the engine or the number and bore of its cylinders, and also the weight of the car unladen. In respect to the other regulations, it is necessary only to mention that no driving certificate can be issued to a person less than 18 years of age, and that, in addition to its ordinary number plate, the car shall be provided with a distinctive plate indicating its nationality. This plate must be carried in a visible position on the back of the car, and must be of oval form, $11\frac{3}{8}$ ins. in width and $7\frac{1}{8}$ ins. in height. The distinctive letters for Great Britain and Ireland are G.B., and must be painted in black capital letters in Latin characters on a white ground. The letters must be at least 4 ins. in height, and the breadth of each line not less than $\frac{5}{8}$ in. These regulations apply to touring in Germany, Belgium, France, Italy, and other countries.

The Royal Automobile Club, Pall Mall, London, S.W., and the Automobile Association and Motor Union, Whitcomb Street, London, W., have been authorized to issue International Travelling passes. Arrangements have been made to examine cars at all important centres in the provinces, etc.

Index Letters of Countries Within the International Convention

Gt. Britain and Ireland—G.B.
Germany—D.
France—F.
Italy—I.
Austria—A.
Spain—E.
Hungary—H.
Russia—R.
Belgium—B.
Greece—G.R.
Sweden—S.
Switzerland—C.H.
Bulgaria—B.G.
Holland—N.L.
Portugal—P.
Roumania—R.M.
Monaco—M.C.
Montenegro—M.N.
Servia—S.B.

Taxes on Visitors' Cars in France

The taxes on cars taken into France by visitors *staying longer than four months* are as follow :—Two-seaters, 60 francs; more than two seats, 90 francs. In addition, a horse-power tax is also levied as follows:— 12 h.p., 5 francs; 13-24 h.p., 7 francs; 25-36 h.p., 9 francs; 37-60 h.p., 12 francs; more than 60 h.p., 15 francs, that is to say, *per* h.p. Thus a 12 h.p. car pays 60 francs tax, and so on. Licences in both cases (number of seats and h.p.) available 360 days.

Exhaustive details of the motoring regulations of foreign countries are given in the foreign handbook issued by the Automobile Association and Motor Union, and also in the handbook of the Royal Automobile Club. These are issued to members.

Exemption of Foreign Visitors' Cars from Revenue Tax

Regulations now provide for exemption from the payment of Inland Revenue tax on cars brought into the United Kingdom for touring purposes by foreigners or visitors from the Colonies. The following is an extract from the official regulations :—

"For the purpose of these regulations the date of registration shall mean :—

"(a) in any case where an international travelling pass is produced, the date of registration inserted in the pass by the officer of Customs and Excise at the port of landing and

"(b) in any other case, the date upon which the motorcar was registered by a council or a county or county borough as shown upon the copy of the entries in the register; or if the car was brought into the United Kingdom in a year subsequent to the year in which the car was so registered, the date on which the car was brought into the United Kingdom in that year, as attested by endorsement upon the copy of the entries by the chief officer of Customs and Excise at the port of landing, and the chief officer of Customs and Excise shall, upon application at the time of the landing of the car, endorse and sign the said copy."

In effect this means that a foreign visitor, on being able to produce the necessary proof that the car has been brought into the country for a short period only, can claim exemption from the tax from the Revenue collecting authority.

Motor Supplies, Repairers, etc., Abroad

Petrol is sold under various names in France everywhere. "Essence" and Moto-Naphtha are usual terms for it. A considerable amount of benzole is imported into France, but this fuel is practically all obtained under contract by the taxi-cab companies. It is very rarely that difficulty is experienced in obtaining petrol even in out-of-the-way villages, and should be bought in a sealed tin or "bidon" of 5 litres, which is rather more than 1 gallon. The price works out at an average of 2s. 6d. per gallon. Octroi duty has to be paid on the measured amount of petrol in the tank when entering certain towns and cities. Engine oil of the best grade costs on the average 3s. 6d. per gallon. In Germany good quality petrol is plentiful, and averages 2s. per gallon. In Italy the price and quality are very variable, 1s. 10d. to 3s. 6d. per gallon being the usual range of charges. Tyres and other standard supplies are readily obtainable in the chief European countries, and garages and repairers are numerous. In France, Germany and Italy the average motor mechanic is usually found very competent and resourceful, and the repair plant in many of the larger shops and garages is unusually up-to-date and complete.

CHAPTER XVII

The Motor Car, the Driver and the Law

Under the Motor Car Act, whilst nobody may drive at a higher speed than twenty miles an hour, a motorist is forbidden, under heavy penalties, from driving recklessly or negligently, or at a speed or in a manner which is dangerous to the public, having regard to all the circumstances of the case. And not only will the nature, condition and use of the highway and the amount of traffic actually on it at the time be taken into account, but all the traffic which might reasonably be expected to be on the highway. A constable may apprehend without warrant the driver who commits within his view any offence coming within this category if the driver refuses his name or address or does not produce his licence on demand, or if his car does not bear the identification mark.

In order to render the law practicable, it is decreed that every motor vehicle shall be able, by means of marks, to be identified at all hours of the day or night, and for this purpose it shall carry in conspicuous places two number plates and be registered with one of the registering authorities, whilst its driver shall hold a driving licence.

Formalities: Registration

This is the first formality to be gone through by a motorist on obtaining a car:

Apply to any County Council or County Borough Council, addressing the letter to the Clerk of the County Council of ——, County Council Offices, —— (giving the chief town of the County) for an application form. Fill in the required particulars and return it with a remittance of twenty shillings. Registration can be made with any authority and not necessarily the authority for the County in which the owner resides.

The registering authority will then allot an identifying mark, which will consist of the index letter or letters of the Council and a number, and will issue a copy of the register to the owner.

A change of ownership must be reported to the Council with whom the car is registered, and a fee of 5s. must be paid for the registration of the change.

If the car should be re-registered with another Council (there is, however, no real need for this), or be destroyed or removed from the country, the fact should be reported, so that the registration may be cancelled. Otherwise a car once registered is always registered, and there is only the one fee to be paid. A registration number once issued cannot be transferred to another car, even if the same type, unless it be first cancelled and re-issued for the other car.

Any change in the appearance of the car should be reported.

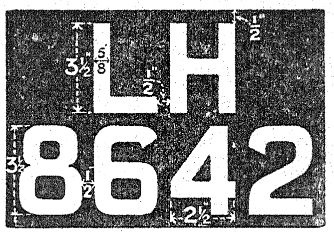
The Identification Marks.—The two plates required to be carried must be supplied by the owner, and they may be either approximately square or oblong, the letters and numbers being either on one or two lines. The letters and figures have to be 3½ inches high, ⅝ths thickness, and total space occupied by each letter or figure (except 1) must be 2½ inches, and must be painted white on a black ground. The Council will inform the owner of the car of the provisions to be

complied with, and the number may be painted either on the car, if the available surface is flat, or on a detachable plate. Metal plates with letters cast on in aluminium and a black background may be used.

The position of the plates on a car must be as follows: One must face forward and the other must face to the rear.

At night time the rear plate of a motor vehicle must be properly illuminated. Any vehicle placed in front of a motor vehicle must carry the front number plate, and any vehicle placed behind a motor vehicle must carry the rear number of the motor vehicle.

The Local Government Board has made special provision for the identification of cars used by or in the service of makers and dealers. A rear light showing red, and an off-side white light forward are compulsory. These must be shown between "one hour after sunset and one hour before sunrise." Head lamps and near side lamp are optional, but the former, for safe driving at night, are indispensable.



Chief dimensions for registration letters and numbers. The illustration depicts the "short" type of plate. Either this or the "long" plate, or one of each, may be used. In the "long" plate the letters and figures are in one row, but a space of $1\frac{1}{2}$ ins. must be left between the letters and first figure. In the "short" plate the distance between the two rows must be $\frac{5}{8}$ in.

Licensing

Every driver of a motor vehicle must be licensed by the Council under whose jurisdiction he for the time being resides, but the regulations do not stipulate for re-licensing in the case of removal on the part of the licensee for that particular 12 months. An application form should be obtained from the County or County Borough Council, and should be returned with a fee of five shillings, which fee has to be paid annually for a renewal of the licence. The licence remains in force for 12 months from date of issue. A licence lost or defaced may be renewed on payment of a fee of one shilling. The licence must be shown to any constable in uniform on demand. Endorsement of a licence can be made for any offence against the regulations, excepting a first or second conviction for exceeding the speed limit. For a third or subsequent conviction endorsement can be made. The police have no power to request that the licence be handed to them. A licence should be renewed a few days before date of actual expiry. An applicant for a car-driving licence must not be under 17 years of age.

Any Council or Local Authority can issue a driving licence to a visitor to the United Kingdom though he may not have a residence within their County or Borough.

Taxation. Regulations Made by the Treasury

1. For the purposes of these regulations the horse-power of any motorcar deriving its motive power wholly from a steam, internal-combustion, or other engine worked by a cylinder or cylinders shall be taken to be:

(a) in the case of a single-cylinder engine the horse-power attributable to the cylinder of the engine;

(b) in the case of an engine having two or more cylinders the sum of the horse-powers attributable to the separate cylinders.

2. The horse-power attributable to any cylinder shall be deemed to be proportional to the square of the internal diameter of such cylinder measured in inches, and shall be determined according to the number of square inches contained in such square, the unit being taken to be:

(a) in the case of a single-acting cylinder having a single piston, one horse-power for every $2\frac{1}{2}$ square inches;

(b) in the case of a single-acting cylinder having two pistons, one horse-power for every $1\frac{3}{5}$ square inches;

(c) in the case of a double-acting cylinder having a single piston, one horse-power for every $1\frac{1}{4}$ square inches.

3. Any motorcar deriving its motive power or any part of its motive power otherwise than from an engine worked by a cylinder or cylinders shall be deemed to be of a horse-power exceeding 12, but not exceeding 15, provided that, where the motive power is derived in part from an engine worked by a cylinder or cylinders, the horse-power of the car shall not be deemed to be less than the horse-power attributable to the cylinder or cylinders of such engine.

4. Where it appears that, in consequence of the exceptional design or construction of the engine of any motorcar, the horse-power as calculated under the foregoing rules is substantially less than the power which the engine is actually capable of developing, the horse-power of the car shall for the purposes of these regulations be taken to be the same as that of a car of equal efficiency deriving its motive power from a cylinder engine of the ordinary type.

5. In measuring cylinders and calculating horse-power, fractions of an inch and fractions of a unit of horse-power are to be taken into account.

These regulations cover petrol engines of the four-stroke cycle and two-stroke cycle types, and steam engines of the single-acting and double-acting types.

Guide to Car Taxes

SINGLE-CYLINDER, any bore not exceeding 4 in. (or 102 mm.)	£2 2 0
SINGLE-CYLINDER, bore exceeding 4 in. (or 102 mm.) but not exceeding 5 7-16ths in. (or 138 mm.)...	£3 3 0
TWO CYLINDERS, bore not exceeding 2 13-16ths in. (72 mm.)	£2 2 0
TWO CYLINDERS, bore exceeding 2 13-16ths in. but not exceeding $3\frac{7}{8}$ in. (98 mm.)	£3 3 0
TWO CYLINDERS, bore exceeding $3\frac{7}{8}$ in. but not exceeding 4 7-16th in. (112 mm.)	£4 4 0
TWO CYLINDERS, bore exceeding 4 7-16th in. but not exceeding $5\frac{1}{2}$ in. (140 mm.)	£6 6 0
FOUR CYLINDERS, any bore not exceeding 2 11-16th in. (or 68 mm.)	£3 3 0
FOUR CYLINDERS, bore exceeding 2 11-16th in., not exceeding 3 5-32nd in. (80 mm.)	£4 4 0
FOUR CYLINDERS, bore exceeding 3 5 32nd in., not exceeding 4 in. (or 102 mm.)	£6 6 0
FOUR CYLINDERS, bore exceeding 4 in., not exceeding 4 17-32nd in. (115 mm.)	£8 8 0
FOUR CYLINDERS, bore exceeding 4 17-32nd in., not exceeding 5 in. (127 mm.)	£10 10 0
FOUR CYLINDERS, bore exceeding 5 in., not exceeding $5\frac{1}{2}$ in. (140 mm.)	£21 0 0

SIX CYLINDERS, any bore not exceeding 2 9-16th in. (65 mm.)	£4 4 0
SIX CYLINDERS, bore exceeding 2 9-16th in., not exceeding 3¼ in. (83 mm.)	£6 6 0
SIX CYLINDERS, bore exceeding 3¼ in., not exceeding 3 11-16th in. (94 mm.)	£8 8 0
SIX CYLINDERS, bore exceeding 3 11-16th in., not exceeding 4 1-16th in. (103 mm.)	£10 10 0
SIX CYLINDERS, bore exceeding 4 1-16th in., not exceeding 5 in. (127 mm.)	£21 0 0
SIX CYLINDERS, bore exceeding 5 in., not exceeding 5½ in. (140 mm.)	£42 0 0

Medical men who use a car in the course of their professional duties pay half the usual taxes. They are also entitled to an allowance of 1½d. per gallon remission of the petrol tax. Forms on which claims must be made are obtainable from local Revenue officials. Receipts for petrol purchased have to be produced.

Medical men are allowed to use their cars for private as well as professional purposes without paying full tax.

An Inland Revenue licence *cannot be transferred* in the event of an owner selling his car in the course of the year. The new owner must take out a separate licence. The holder of a current revenue licence, however, who has disposed of one car and got a new one is not required to take out another licence, providing the new car is of the same class as the former one. Should it be rated at a higher revenue tax, however, the authorities will allow the amount of the tax already paid to count on the new tax. A car owner must pay 15s. male servant licence duty per annum for the driver of his car. For a mechanic or engineer who occasionally drives no licence is required. The use of armorial bearings or heraldic devices on a car entails a tax of £2 2s. per year.

A reduction of half licence duty is made on cars obtained between 1st October and 31st December in each year.

Exemption from car taxes is only granted in cases where the car is *specially made for and used solely for the conveyance of goods.* The owner's name and trade address must be painted on the bodywork.

No allowance is made in the existing taxation regulation for cars of old pattern. As the engines of these cars usually have a bore out of all proportion to the power the tax falls unusually heavy on such cars. It is probable that future legislation may to some extent make allowance in such cases.

Speed Restrictions

The Act gives authority to the Local Government Board to close any specified stretch of road to motor traffic entirely, or to restrict the speed of motors upon it, if it be shown by the local authority that for some reason it is particularly dangerous to motor traffic, or if motor traffic upon it would constitute a source of danger. A large number of such speed-limit areas are now in operation. In all such cases the local authority must erect and maintain notice boards at the beginning and end of each such length of road, and it has been decided that the following shall be the signals:—

(1) For ten miles or lower limit of speed: A round white ring, eighteen inches in diameter, with plate below giving limit in figures.

(2) For prohibition: Red solid disc, eighteen inches in diameter.

(3) For caution, dangerous corners, cross-roads, or precipitous places: Hollow red equilateral triangle.

(4) All other notices under the Act to be on diamond-shaped boards.

What has to be Done Before Using a Car

(1) Have number-plates properly fitted.

(2) The driver must have the driving licence in his possession.

(3) Have paid the Inland Revenue tax, the regulation specifying "within 21 days of becoming liable to the tax, or not later than the end of January in each year." An official form can be obtained at any money order office, and local council authorities, to whom the collection of the duty has been deputed.

(4) Have a set of reliable lamps, and provide for illumination of rear number-plate.

(5) Have a good horn or warning instrument to give audible warning.

(6) If the car is hired, see that it has a number back and front duly registered.

Motorists are cautioned against using temporary or improvised number-plates, such as chalked numbers on cardboard or paper. The police have instructions to prosecute in such cases. Proper plates of japanned tin can be got for a few shillings from any motor or accessory dealer, or the more substantial cast plate may be used. Car drivers should take special care to see that their rear lamp is a good one, well trimmed, and *not liable to jolt out.* If the light goes out it may result in the driver being heavily fined.

Motorists must Respect the Rights of Road Users

Due regard and consideration for the rights of other road users must always be exercised by the motorist. He must never pass traffic going in the same direction on the near side. Pass on the right, and invariably give ample warning by sounding the horn. If the driver of a restive horse signals for the motorist to slow up, this request should invariably be acceded to. Otherwise, in the event of an accident, the motorist would be held in a court of law as guilty of contributory negligence. When travelling along winding roads and country lanes, the pace of the car should be kept well in hand, and the horn sounded continually. When driving on muddy roads, where there are a number of pedestrians about, it is only common courtesy to drive slowly, so as not to cause inconvenience from mud being splashed about by the wheels, etc.

In case of accident in which he may be involved, a motorist must stop and render what help or give what information he can.

When turning from the left side of the road to the right hand (or wrong side) a careful driver will slow down a good deal, and before turning look round to his right to warn any oncoming traffic, especially cyclists; a driver should always signal by projecting the right arm for a moment as a warning. *The use of an exhaust cut-out on public roads is now prohibited by law.*

The patrols of Road Guides and Scouts organized by the R.A.C. and A.A. are now at the services of motorists, and are able to supply useful information as to road conditions, or to render help and first-aid in case of accident. All the main roads in the kingdom are patrolled, so that one need rarely be at a loss for information.

Features of the Patent Act

This short article deals with some of the more important matters of interest to those who contemplate applying for a patent, and the following five points are the most important ones. The Comptroller has absolute power to refuse an application for a patent unless the subject matter is new. This means that not only must there be a difference between the alleged advantages of the invention of the new claimant and those of an existing one, but the new claimant must

also show that he has used specific inventive faculty in producing such differences.

Cases under the International Convention may be filed at the Patent Office, from abroad, within twelve months of the date of filing in the original country as before. For example: suppose that "A," who resides in Germany, lodged a specification at the German Patent Office on January 2nd, and that "B," an Englishman, does not lodge a specification of the English Patent Office until October 3rd. "B's" apparatus has some slight resemblance to that covered by "A's" application, but he does not know that "A" exists until "A" comes to lodge his German patent in England on December 31st, when "B's" application will be affected thereby on the ground of firm grant. In the old rule, "A's" specification did not constitute anticipation, because his patent had not been published in "B's" country at the time the latter's application was accepted.

The efficient marking of patented articles, which are on sale, has been made more stringent. Formerly, it was not compulsory to mark a patented article at all, and it was only done by the manufacturer as self-advertisement, and to save infringement; but, now, this has been completely changed, and every article has to be marked, not only with the patent number, but also with the date when the application of the patent was filed. In the event of two parties going to law on account of alleged infringement, if the plaintiff's goods are not marked according to the requirements of law, even if he win his case, he will be unable to recover damages. Section 27 is an important one. It states that: "At any time not less than four years after the date of a patent, and not less than one year after the passing of this Act, any person may apply to the Comptroller for the revocation of the patent on the ground that the patented article or process is manufactured or carried on exclusively or mainly outside the United Kingdom." The Comptroller has it in his power to revoke the patent forthwith, or "after such reasonable interval as may be specified in the order, unless in the meantime it is shown to his satisfaction that the patented article or process is manufactured or carried on within the United Kingdom to an adequate extent."

Additions to a Patent

It will be noticed that "interested persons" or some such similar words are not used in this section, but that the Act distinctly states that "any person" may apply for the revocation of an existing patent, and it is within the powers vested in the Comptroller, who has practically the law in his own hands, to do as he thinks fit. It is extremely unlikely that any but an interested person would apply. Section 19 embodies a regulation which is of advantage to the inventor, inasmuch as it allows new and desirable additions to be made to an existing patent without any additional taxes. Such a modification is termed a "patent of addition," and it falls void when the original patent expires. In sub-section 4, of the same section, it reads: "The grant of a patent of addition shall be conclusive evidence that the invention is proper subject matter for a patent of addition, and the validity of the patent shall not be questioned on the ground that the invention ought to have been the subject of an independent patent."

The Act also contains a section (No. 20) relating to the restoration of lapsed patents from any of various causes. This rule is of advantage to inventors, because patents which have lapsed "owing to the failure of the patentee to pay the required fee within the prescribed time," can be revived upon an application to the Comptroller. The application must state reasons why the taxes have not been regularly discharged, and it must also show that the failure to pay the taxes was

unintentional; further, it must prove that no "undue delay has occurred in the making of the application." Any such application will be announced to enable opposition to the restoration to be made.

A "provisional" specification may be filed and protection of an idea obtained by an inventor at a cost of £1 for the Government stamp. This protection lasts for a period of six months (instead of nine months as formerly), during which time the inventor can proceed to develop the patent or negotiate for it being taken up. At the end of the six months an inventor has to file his full specification and drawings, for which the Patent Office charge a fee of £3, with £1 as sealing fee on allowance of patent in respect of the additional work now performed for searching the records for fifty years back. In view of the complexities and technicalities involved in the drafting of specifications and preparation of drawings for obtaining patents, the help of a patent agent specializing in the subject matter of the patent is advisable.

Regulations as to Petrol Storage

Regulations made by the Secretary of State under Section 5 of the Locomotives on Highways Act as to the Keeping and Use of Petroleum for the purposes of light locomotives.

1. The following shall be exempt from licence under the Petroleum Act, 1871, namely:—

(*a*) Petroleum spirit which is kept for the purpose of, or is being used on, light locomotives when kept or used in conformity with these regulations.

(*b*) Petroleum spirit which is kept for the purpose of, or is being used on, light locomotives by, or by authority of, one of His Majesty's principal Secretaries of State, the Admiralty, or other department of the Government.

2. These regulations shall apply to petroleum spirit which is kept for the purpose of, or is being used on, light locomotives, and for which (save as hereinafter provided) no licence has been granted by the local authority under the Petroleum Act, 1871, and shall not apply to petroleum spirit which is kept for sale or partly for sale and partly for use on light locomotives, and which must be kept in accordance with the provisions of the Petroleum Acts as heretofore, except that Regulations 13 and 14 shall apply to petroleum spirit which is kept partly for sale and partly for use on light locomotives. These regulations shall not apply to the keeping or use of petroleum spirit by or under the contro of any Government department. Such keeping or use may be the subject of regulations to be made by the department concerned.

3. Where for any special reason a person keeping petroleum spirit for the purpose of light locomotives applies for a licence under the Petroleum Act, 1871, and the local authority see fit to grant such licence, such petroleum spirit shall be subject only to Regulations 8 to 15 and the conditions of such licence, in so far as the said conditions are not contrary to the said Regulations 8 to 15.

4. Where a storehouse forms parts of, or is attached to, another building, and where the intervening floor or partition is of an unsubstantial or highly inflammable character, or has an opening therein, the whole of such building shall be deemed to be the storehouse, and no portion of such storehouse shall be used as a dwelling or as a place where persons assemble. A storehouse shall have a separate entrance from the open air distinct from that of any dwelling or building in which persons assemble.

5. The amount of petroleum spirit to be kept in any one storehouse, whether or not upon light locomotives, shall not exceed 60 gallons at any one time.

6. Where two or more storehouses are in the same occupation and are situated within 20 feet of one another, they shall for the purposes of these regulations be deemed to be one and the same storehouse, and the maximum amount of petroleum spirit prescribed in the foregoing regulation shall be the maximum to be kept in all such storehouses taken together. Where two or more storehouses in the same occupation are distant more than 20 feet from one another, the maximum amount shall apply to each storehouse.

7. Any person who keeps petroleum spirit in a storehouse which is situated within 20 feet of any other building, whether or not in his occupation, or of any timber stack or other inflammable goods not owned by him, shall give notice to the local authority under the Petroleum Acts for the district in which he is keeping such petroleum spirit, that he is so keeping petroleum spirit, and shall renew such notice in the month of January in each year during the continuance of such keeping, and shall permit any duly authorised officer of the local authority to inspect such petroleum spirit at any reasonable time. This regulation shall not apply to petroleum spirit kept in a tank forming part of a light locomotive.

8. Every storehouse shall be thoroughly ventilated.

9. Petroleum spirit shall not be kept, used or conveyed except in metal vessels so substantially constructed as not to be liable, except under circumstances of gross negligence or extraordinary accident, to be broken or become defective or insecure. Every such vessel shall be so constructed and maintained that no leakage, whether of liquid or vapour, can take place therefrom.

10. Every such vessel, not forming part of a light locomotive, when used for conveying or keeping petroleum spirit, shall bear the words "petroleum spirit highly inflammable" conspicuously and indelibly stamped or marked thereon, or on a metallic or enamelled label attached thereto, and shall be of a capacity not exceeding two gallons.

Provided that this limitation of capacity shall not apply in any place of storage which is licensed under the Petroleum Act, 1871, unless such limitation is required by the conditions of the licence.

11. Before repairs are done to any such vessel, that vessel shall, as far as practicable, be cleaned by the removal of all petroleum spirit and of all dangerous vapours derived from the same.

12. The filling or replenishing of a vessel with petroleum spirit shall not be carried on, nor shall the contents of any such vessel be exposed in the presence of fire or artificial light, except a light of such construction, position, or character, as not to be liable to ignite any inflammable vapour arising from such spirit, and no fire or artificial light capable of igniting inflammable vapour shall be brought within dangerous proximity of the place where any vessel containing petroleum spirit is being kept.

13. In the case of all petroleum spirit kept or conveyed for the purpose of, or in connection with, any light locomotive, (*a*) all due precautions shall be taken for the prevention of accidents by fire or explosion, and for the prevention of unauthorised persons having access to any petroleum spirit kept or conveyed, and to the vessels containing or intended to contain, or having actually contained, the same; and (*b*) every person managing or employed on, or in connection with, any light locomotive shall abstain from every act whatever which tends to cause fire or explosion, and which is not reasonably necessary, and shall prevent any other person from committing such act.

14. In the storehouse or in any place where a light locomotive is kept or is present, petroleum spirit shall not be used for the purpose of cleaning or lighting, or as a solvent or for any purpose other than as fuel for the engine of a light locomotive.

Provided that where due precaution is taken to prevent petroleum spirit from escaping into a sewer or drain and provision made for disposing safely of any surplus petroleum spirit and where no fire or naked light is present, quantities not exceeding one gill may be used for cleaning of a light locomotive at a safe distance from any building, place of storage of inflammable goods, or much frequented highways, or for the repair of tyres, under suitable precautions.

This regulation shall apply to premises on which petroleum spirit is kept for the purpose of, or is being used on, light locomotives, whether such premises are licensed or not, unless the local authority see fit, in the case of licensed premises, to grant an exemption by a special term of the licence.

15. Petroleum shall not be allowed to escape into any inlet or drain communicating with a sewer.

These regulations apply to benzole, although technically it is not "petroleum" spirit. The same risks are attendant on its use and general manipulation.

Licence to Sell Petrol or Other Fuel

A licence is necessary to sell inflammable spirit used for motorcar propulsion. This is obtainable from the local authority under the Petrol Act. Application should be made at the local Town Hall, District Council Offices, or Head Police Office for the district, from whom further information can be obtained.

INDEX MARKS

ENGLAND and WALES.

Counties and County Boroughs arranged in alphabetical order with index marks.

Counties. 1.	Index Mark. 2.
Anglesey	E Y
Bedfordshire	B M
Berkshire	B L
Breconshire	E U
Buckinghamshire	B H
Cambridgeshire	C E
Cardiganshire	E J
Carmarthenshire	B X
Carnarvonshire	C C
Cheshire	M
Cornwall	A F
Cumberland	A O
Denbighshire	C A
Derbyshire	R
Devonshire	T
Dorset	F X
Durham	J
Ely, Isle of	E B
Essex	F
Flintshire	D M
Glamorganshire	L
Gloucestershire	A D
Herefordshire	C J
Hertfordshire	A R
Huntingdonshire	E W
Kent	D
Lancashire	B
Leicestershire	A Y
Lincolnshire, Parts of Holland	D O
Lincolnshire, Parts of Kesteven	C T
Lincolnshire, Parts of Lindsey	B E

Counties. 1.	Index Mark. 2.
London (9 series) {A, LC, LA,	LN, LB, LD, LE, LF, LH
Merionethshire	F F
Middlesex	M X & H
Monmouthshire	A X
Montgomeryshire	E P
Man, Isle of	M N
Norfolk	A H
Northamptonshire	B D
Northumberland	X
Nottinghamshire	A L
Oxfordshire	B W
Pembrokeshire	D E
Peterborough, Soke of	F L
Radnorshire	F O
Rutland	F P
Salop	A W
Somerset	Y
Southampton	A A
Staffordshire	E
Suffolk, East	B J
Suffolk, West	C F
Surrey	P
Sussex, East	A P
Sussex, West	B P
Warwickshire	A C
Westmoreland	E C
Wight, Isle of	D L
Wiltshire	A M
Worcestershire	A B
Yorkshire (E. Riding)	B T
Yorkshire (N. Riding)	A J
Yorkshire (W. Riding)	C
County Boroughs.	
Barrow-in-Furness	E O

County Borough. 1.	Index Mark. 2
Bath	F B
Birkenhead	C M
Birmingham	O
Blackburn	C B
Bolton	B N
Bootle	E M
Bournemouth	E L
Bradford (Yorkshire)	A K
Brighton	C D
Bristol	A E
Burnley	C W
Burton-upon-Trent	F A
Bury	E N
Canterbury	F N
Cardiff	B O
Chester	F M
Coventry	D U
Croydon	B Y
Derby	C H
Devonport	D R
Dudley	F D
Eastbourne	H C
Exeter	F J
Gateshead	C N
Gloucester	F H
Great Yarmouth	E X
Grimsby	E E
Halifax	C P
Hanley	E H
Hastings	D Y
Huddersfield	C X
Ipswich	D X
Kingston-upon-Hull	A T
Leeds	U
Leicester	B C

County Borough. 1.	Index Mark. 2.
Lincoln	F E
Liverpool	K
Manchester	N & N A
Middlesbrough	D C
Newcastle-upon-Tyne	B B
Newport (Monmouth)	D W
Northampton	D F
Norwich	C L
Nottingham	A U
Oldham	B U
Oxford	F C
Plymouth	C O
Portsmouth	B K
Preston	C K
Reading	D P
Rochdale	D K
Rotherham	E T
St. Helens	D J
Salford	B A
Sheffield	W
Southampton	C R
Southport	F Y
South Shields	C U
Stockport	D B
Stoke-on-Trent	E H
Sunderland	B R
Swansea	C Y
Walsall	D H
Warrington	E D
West Bromwich	E A
West Ham	A N
West Hartlepool	E F
Wigan	E K
Wolverhampton	D A
Worcester	F K
York	D N

INDEX MARKS

SCOTLAND. / IRELAND.

Registering Council. 1. (Scotland)	Index Mark. 2.	Registering Council. 1. (Scotland)	Index Mark. 2.	Authority. (Ireland)	Index Mark.	Authority. (Ireland)	Index Mark.
County Council of—		*County Council of—*		*County Council of—*		*County Council of—*	
Aberdeen	S A	Orkney	B S	Antrim	I A	Monaghan	B I
Argyll	S B	Peebles	D S	Armagh	I B	Queen's County	C I
Ayr	S D	Perth	E S	Carlow	I C	Roscommon	D I
Banff	S E	Renfrew	H S	Cavan	I D	Sligo	E I
Berwick	S H	Ross and Cromarty	J S	Clare	I E	Tipperary,	
Bute	S J	Roxburgh	K S	Cork	I F	N. Riding	F I
Caithness	S K	Selkirk	L S	Donegal	I H	Tipperary,	
Clackmannan	S L	Stirling	M S	Down	I J	S. Riding	H I
Dumfries	S M	Sutherland	N S	Dublin	I K	Tyrone	J I
Dumbarton	S N	Wigtown	O S	Fermanagh	I L	Waterford	K I
Elgin	S O	Zetland	P S	Galway	I M	West Meath	L I
Fife	S P			Kerry	I N	Wexford	M I
Forfar	S R	*Town Council of—*		Kildare	I O	Wicklow	N I
Haddington	S S	Aberdeen	R S	Kilkenny	I P		
Inverness	S T	Dundee	T S	King's County	I R	*Council of the County*	
Kincardine	S U	Edinburgh	S	Leitrim	I T	*Borough of—*	
Kinross	S V	Glasgow	G	Limerick	I U	Belfast	O I
Kirkcudbright	S W	Govan	U S	Londonderry	I W	Cork	P I
Lanark	V	Greenock	V S	Longford	I X	Dublin	R I
Linlithgow	S X	Leith	W S	Louth	I Y	Limerick	T I
Midlothian	S Y	Paisley	X S	Mayo	I Z	Londonderry	U I
Nairn	A S	Partick	Y S	Meath	A I	Waterford	W I

English-French Motor Dictionary

English.	*French.*
Automobile (small)	Voiturette
Accelerator ..	.. Accélérateur
Accumulator	.. Accumulateur (M)
Adjusting screw	.. La Vis de réglage
Admission pipe	.. Tuyau d'entrée
Air passage, hot	.. Tuyau pour l'entrée de l'air chaud
Air pump ..	.. Pompe d'air
Air tube ..	.. Chambre d'air
Air valve ..	.. Soupape d'air
Alcohol ..	.. Alcool
Ascent	.. Montée
Automatic induction valve ..	Soupape d'admission automatique
Axle	.. Essieu
Anti-slipping Device (non-skid)	Antiderapant
Back-fire ..	.. Explosion prématurée
Back wheel ..	.. Roue d'arrière
Ball bearings	.. Coussinets à billes
Band brake ..	.. Frein à bande
Barrel or pump	.. Corps de pompe
Ball joint ..	.. Joint Sphèrique
Batteries (primary)	Pile primaire
Battery, dry ..	.. Pile séche
Bearing	.. Coussinet palier
Bearings, roller	.. Coussinets à rouleaux
Bell, alarm ..	.. Grelot, Timbre avertisseur
Belt	.. Courroie
Belt fastener	.. Agrafe pour courroie
Benzine ..	Essence de pétrole
Bevel wheel	.. Roue conique
Block chain ..	.. Chaîne à galets
Boiler	.. Chaudière
Bolt (hexagonal)	.. Boulon hexagonal
Bolt (round head)	Boulon à tête ronde
Boltscrew ..	.. Boulon à vis
Bonnet	.. Capôt
Bore of the cylinder ..	Alésage du cylindre
Box spanner ..	.. Clef à douille
Brake	.. Frein
Brake band ..	.. Ruban du frein
Brake drum ..	.. Frein à tambour
Brake lever ..	.. Levier du frein
Brake lock ..	.. Frette de friction
Brake rod ..	.. Tige de frein
Brazing ..	.. Brasure
Brass ..	.. Cuivre jaune
Burner ..	.. Bruleur
Breakdown ..	.. Panne
Bridge	.. Pont
Bush	.. Coussinet
Cam, exhaust	.. Came d'échappement
Cam, gear ..	.. Distribution à came
Cardan joint	.. Cardan
Centrifugal pump	Pompe centrifuge
Chain	.. Chaîne
Chain wheel	.. Roue de chaîne
Change of speed	Changement de vitesse
Change speed lever	Levier de changement de vitesse
Circulating pipe ..	Tuyau de circulation
Clutch ..	.. Embrayage
Clutch friction cone ..	.. Cône de friction
Clutch, leather ..	Cuir
Clutch spring	.. Ressort d'embrayage
Cogs and teeth ..	Dents en bois et en fer
Coil	.. Bobine
Coil, induction ..	Bobine d'induction
Collar	.. Collier
Combustion chamber	.. Culasse
Components	.. Pièces détachées
Compression cam lever	Billette de commande
Compression tap	Robinet de compression
Connecting bolt (hollow axle)	Axe creux de pièce d'assemblage
Connecting pipe	Tuyau de jonc- [tion
Connecting rod ..	Bielle
Connection ..	.. Embrayage
Contact breaker	Interrupteur
Contact (commutator for breaking) ..	Disjoncteur

English.	*French.*
Contact screw, platinum tipped	Vis de contact platinée
Control	Contrôle
Cooling, air ..	Refroidissement par air
Cooling by water	Refroidissement par eau
Copper	Cuivre rouge
Cord	Corde
Cotter	Clavette de manivelle détachable, coin
Counter balance	Equilibrier
Countershaft ..	Contre-arbre
Coupling	Accouplement
Coupling pin and nut	Vis et écrou pour jonction d'une chaîne
Crank	Manivelle
Crank axle	Arbre des manivelles
Crank case bush ..	Bague du carter
Crank chamber ..	Carter
Crank pin	Courillon de manivelle
Crank shaft ..	Arbre à mani- [velle
Crank shaft feather (or key)	Clavette
Current (charging)	Courant de charge
Cylinder	Cylindre
Cylinder head ..	Culasse
Custom House ..	Douane
Dangerous hill ..	Descente dangereuse
Differential	Différentiel
Distance recorder	Odomètre
Double-thread ..	Double filet
Driving axle ..	Essieu moteur
Driving chain ..	Chaîne de transmission
Driving pulley ..	Poulie jante
Driving shaft ..	Arbre primaire
Drum	Tambour
Dust	Poussière
Efficiency	Rendement
Elastic	Elastique
Electric lamp ..	Lampe électrique
Electric motor ..	Moteur électrique
Emery	Emeri
Enamel	Email
Exhaust	Echappement
Exhaust cam ..	Pignon came
Exhaust cam axle	Axe du pignon came
Exhaust elbow connection	Pipe de refoulement

English.	*French.*
Exhaust, port ..	Lumière d' échappement de la vapeur
Exhaust valve ..	Soupape d'échappement
Exhaust valve spring	Ressort du clapet d'échappement
Fan	Ventilateur
Feed pipe	Tube alimentaire
Feed pump	Pompe d'alimentation
Felt	Feutre
Fibre, vulcanised	Fibre vulcanisèe
File	Lime
Flange	Bride
Flexible coupling	Accouplement flexible
Float	Flotteur
Fly-wheel	Volant
Foot-brake	Frein á pédale
Fork	Fourche
Frame	Chassis
Freezing	Gelant
Friction	Frottement
Front axle	Essieu d'avant
Front wheel ..	Roue d'avant
Frost	Gelée
Gauge	Indicateur
Gear	Engrenage
Gear, bevel	Engrenage à biseau, Engrenage conique
Gear box	Boîte de vitesse
Gear, change speed	Changement de vitesse
Gloves	Gants
Goggles	Lunettes
Governor	Regulateur
Governor, shaft ..	Arbre du régula-
Gradient	Pente [teur
Grind, to	Aiguiser
Grooved pulley ..	Poulie à gorge
Gudgeon	Goujon
Gudgeon pin ..	Goujon
Guide rod	Tige de direction
Handle	Manette
Headlight	Phare
High-tension current	Courant de haute tension
Hill climbing ..	Gravir des rampes
Honeycomb radiator	Radiateur à nid d'abeille
Horse-power (H.P.)	Cheval-vapeur
Hot	Chaudé
Ignition, advance	L'allumage avance à

English.	*French.*
Ignition, electric, by magneto	Allumage par magneto
Ignition lever	Manette d'allumage
Ignition, retard	L'allumage retard à
India-rubber	Caoutchouc
Inlet valve mechanically operated	Soupape d'alimentation
Inner tube (tyre)	Chambre à air
Key	Clef, clavette, calle
Knuckle joint	Joint de coussinet, en charnière
Lamp bracket	Porte lanterne
Leather washer	Rondelle de cuir
Left-handed screw	Vis filetée à gauche
Lever	Levier ; manette
Licence	Permit
Lifting jack	Chevre : cric
Lock-nut	Contre écrou
Lubrication	Huilage
Lubricator	Graisseur
Mixture, explosive	Mélange explosif
Motor, four-cycle	Moteur à quatre temps
Motor, two-cycle	Moteur à deux temps
Mudguard	Garde-boue
Needle valve	Tige de contrôl d'essence
Neutral	Neutre
Non-skid (tyre)	Anti-derapant
Notched quadrant	Secteur denté
Oil	Huile
Out of gear	Débrayé
Outer cover (tyre)	Enveloppe
Paraffin	Huile de pétrole
Petrol	Essence de pétrole
Petrol tank	Réservoir à l'essence
Pin, split	Goupille fendue
Piston	Piston
Piston ring	Segment du piston
Piston stroke	Course du piston
Platinum	Platine
Pliers	Pince
Plug, sparking	Bougie
Puncture	Crevaison de pneumatic
Railway	Chemin de fer
Rim (wheel)	Jante
Ratchet	Cliquet
Rear entrance	Entrée d'arrière
Repairing outfit	Trousse à réparation
Retard (to slow up)	Ralentir
Reverse	Marche arrière
Reversing gear	Changement de marche
Revolution	Tour
Rivet	Rivet
Roller	Rouleau
Steel	Acier
Screw-driver	Tournevis
Sheet iron	Tôle
Silencer	Silencieux
Skid, to	Deraper
Soap	Savon
Spanner	Clef
Spare part	Pièce de reserve
Spark	Etincelle
Spindle	Fuseau
Spoke	Rayon
Sprag	Béquille
Shaft	Arbre
Spring	Ressort
Sprocket wheel	Roue à chaîne
Starting handle	Manivelle de mise en marche
Steering gear	Direction
Steering wheel	Roue directrice
Suction	Aspiration
Solder	Soudure
Square	Carre
Teeth of wheels	Dents de roues
Throttle	Manivelle l estrangelment
Tool box	Boîte d'outils
Train, goods	Petite vitesse
Train, passenger	Grande vitesse
Tank	Réservoir
Tap	Robinet
Tyre (Rubber)	Caoutchouc bandage
Tyre lever	Démonte pneu
Turn (road)	Virage
Valve	Soupape
Washer	Rondelle
Water circulation	Circulation d'eau
Waterproof	Imperméable
Water tank	Réservoir d'eau
Water jacket	Chemise d'eau
Wheel	Roue
Wire gauze	Toile métallique
Wire rope	Cable; corde de [fer
Wood	Bois
Works	Usine
Workshop	Atelier
Worm wheel	Rue hélice
Wrench (spanner)	Clef

Car Owner's Monthly Upkeep Tables

Month	New Tyres, Covers.	Air Tubes Repairs, Sundries.	Petrol.	Benzol,	Paraffin.	Lubricating Oil, Grease.	Ignition Details.	Lighting.	Mechl. Renewals	Small Parts.	Repairs and Adjustments	Sundries.	Totals.	Mileage.
Totals														

Readers' Notes

Car Owner's Monthly Upkeep Tables

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Totals														

Readers' Notes